
THE MAGIC LANTERN
ITS CONSTRUCTION & MANAGEMENT
Ward Lock & Co London & New York
SHOWING: how to make a MAGIC LANTERN and how to produce BEAUTIFUL & STARTLING EFFECTS

# THE MAGIC LANTERN.

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# MAGIC LANTERN:

## Its Construction and Management.

BY

"A PRACTISED HAND."

*AN ILLUSTRATED MANUAL*

SHOWING HOW TO MAKE A MAGIC LANTERN AND HOW TO PRODUCE MANY BEAUTIFUL AND STARTLING EFFECTS

*WITH UPWARDS OF EIGHTY EXPLANATORY ENGRAVING*

WARD, LOCK, AND CO.
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# PREFACE.

THE present work on the Magic Lantern first appeared in the pages of *Amateur Work Illustrated*, and is now issued in book form in the belief that it will supply a long-felt want. There are many magic lantern manuals, but they are all confined to explaining how to use the instrument; whereas this little book tells the amateur not only how to use it but how to make it. There is a growing desire on the part of amateurs to make all their own apparatus; and many, no doubt, have felt a desire to construct a magic lantern, but have been deterred from attempting to do so from not having been able to procure a practical work on the subject. There is no pleasanter way of spending one's spare time than in making apparatus for one's own use; and of all the instruments which the amateur is likely to try his hand at making, none is so useful—none is capable of affording so much instruction and delight to oneself and one's friends—as the magic lantern.

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# THE MAGIC LANTERN:

## *ITS CONSTRUCTION AND MANAGEMENT.*

## CHAPTER I.

*HISTORY OF THE LANTERN—THE TOY LANTERN—THE PHANTASMAGORIA LANTERN—THE NEW LANTERN AND HOW TO MAKE IT—THE SLIDE-STAGE.*

THE Magic Lantern is such a popular and useful instrument that I feel sure this little work on "Its Construction and Management" will be acceptable to many readers. It is chiefly intended for those amateurs who wish to make a magic lantern for themselves, and who having made one wish to know how to work it so as to obtain the best results.

### History of the Lantern.

A few words on the history of the instrument may not be out of place by way of introduction. "Who made the first magic lantern?" is a question that is often asked; but it is one that is not easily answered, inasmuch as we are not sure when the instrument was invented. We have reason to believe that the ancient Egyptians knew how to project "shadow pictures" on to the walls of their temples, by means of lenses or mirrors, the sun forming the source of light, and rude

representations of various objects serving as slides. But an exhibition of this kind, though it must have seemed very wonderful to the spectators at the time, cannot be called a magic lantern entertainment, for the first account of which we have to come to a much more recent period.

According to Dr. Young, and some other writers, the honour of having invented the magic lantern and first publicly exhibited it is to be ascribed to the famous Roger Bacon, who lived in the thirteenth century. The

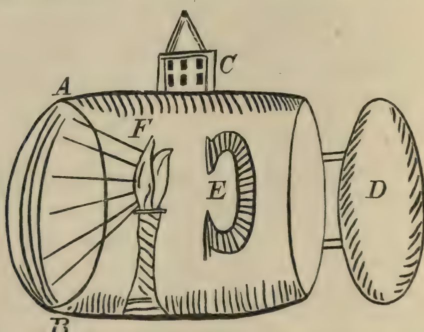


Fig. 1.—The First Magic Lantern. Copy of an Engraving in an old Latin Work.

first description of a magic lantern appears in a work published at Rome by Ludovici Grignani in the middle of the seventeenth century, entitled *Ars Magna Lucis et Umbræ*, "The Great Art of Light and Shadow" (*in decem libros digesta*). In this work, a copy of which can be seen at the British Museum, there is a quaint illustration of the instrument, reproduced in Fig. 1. The learned Jesuit, Athanasius Kircher, is the author of the work, and his description is most interesting. "*Lucernam artificiosam construere, quæ in remota distantia scripta legenda exhibeat.*" And he goes on to explain that the lantern is

of cylindrical shape, with a concave reflector, A B, at one end. F is the *flamma candelæ* or source of light; E is the handle; D the lens, a double convex glass, between which and the end of the lantern is the aperture for the insertion of the slides; C is the *infumibulum* or chimney. Kircher does not pretend to be the inventor of this lantern, which was in use before his time. He, however, designed another form of lantern, which is illustrated and described by him in a later edition of *Ars Magna Lucis et Umbræ*. Kircher's lantern must have been inconveniently large and unwieldy. The body of the instrument in fact was of such dimensions as to enable the exhibitor to stand in it, which he probably did all the time the "entertainment" lasted. At first Kircher appears to have placed his lantern in the room with the spectators, as the illustration on page 768 of this later edition of his work shows; but he afterwards placed it in an adjoining apartment. The rays of light passed through a hole in the partition and were projected on to the opposite wall. His source of light was a smoky oil lamp, either supported on a stand with a reflector behind it, or suspended, as shown in his second illustration, from the top of the box by a chain. The lenses were fitted into a tube inserted in an aperture in front of the box and on a line with the flame: the slides must have been somewhat similar to the toy sliders of these days: they were painted on strips of glass, and probably represented ghosts, hobgoblins, and other uncanny creatures. Curiously enough, in Kircher's engravings the slides are shown in the lantern turned the right way; that is to say, not upside down, as we know they must be turned in lanterns of the ordinary construction. In his first illustration we see that he had eight little pictures on

a slide, which is about the number that we usually have now on the toy sliders.

In an old book the "Magick Lanthorn," as it is called, is described as an "optick machine by means of which are represented in an obscure place many hideous shapes," and it is certain that the instrument was first used to startle and terrify the people. It is only in comparatively recent times that it has become a source of delight to old and young.

## The Toy Lantern.

Magic lanterns vary as much in price as most other optical instruments; the cheapest lantern, which is only suitable for amusing children, does not cost more than a few shillings, while some of the best dissolving-view lanterns may cost, with the necessary accessories, as much as thirty pounds, or more.

The toy lantern is the simplest form of the instrument. As its name implies, it is little better than a plaything, and is only used for the amusement of small children. Yet in all probability better results are obtained from it than Kircher was able to obtain from his large apparatus. These lanterns are numbered 1 to 6 in most catalogues, and vary in price from a couple of shillings or so to a pound or more. In the old form of toy lantern the source of light was a small oil-lamp, which gave a dull yellowish flame. In the toy lanterns now constructed the common oil-lamp has been superseded by a small neatly-made mineral oil-lamp, which gives a much whiter and steadier light. Owing to the disagreeable smell so often given off by these latter, when not properly trimmed or turned up, many parents prefer the old-fashioned lamp, which, when properly managed, answers well enough for the amuse-

ment of the little folks. These lanterns vary in price according to the diameter of the condenser or inner lens: the smallest and cheapest have condensers of about $1\frac{3}{8}$ inch in diameter; those of medium size, say Nos. 3 and 4, have condensers of 2 and $2\frac{1}{2}$ inches in diameter, and the largest, the No. 6, has a condenser of 3 inches in diameter. With the first a disc of about 3 feet will be obtained at a distance from the screen of between 3 and 4 feet, and with the largest an 8 or 10 feet disc at about 10 or 12 feet from the screen. As a rule the lantern requires to be placed about one-third as far again from the screen as the diameter of the disc required. The new toy lanterns are usually sold in boxes, with a set of about a dozen sliders and full directions for use. Many of them are made in France, and are sold for a mere song.

## The Phantasmagoria Lantern.

The so-called phantasmagoria lantern is a superior instrument. It is usually supplied with a double or compound condenser, and an achromatic objective. The condenser is either $3\frac{1}{2}$ or 4 inches in diameter, according to the price of the instrument. All these lanterns are generally made of tin and japanned; the slide-stage or front part of the instrument, the lens-tubes, and the screws, etc., are of brass. In the best instruments the lantern is cased in mahogany, or rather the body of the instrument is made of polished mahogany, and lined with tin. A lantern of this description is shown in Fig. 2.

## The New Lantern and How to Make It.

The lantern that I am now about to describe is one of the new forms of the instrument, and is of the

standard size. It would cost to buy new about four pounds; but of course it could be made at home for less, the actual value of the materials used in its construction being very little, if we except the condenser and the objective. The amateur who is a photographer can adapt one of his portrait lenses as

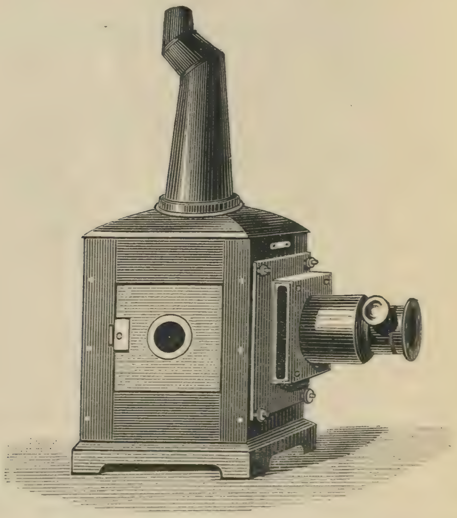

Fig. 2.—The Phantasmagoria Lantern.

an objective for it, and thus save the cost of a new glass.

It is a good, strong lantern, handy and portable, and for those who have had some practice in the "art"—if I may call it an art—of working in sheet metal, not difficult to make. Any kind of slide may be shown in it, and it is well suited for exhibiting what are called "effects," some of which I will describe later on.

All magic lanterns may be said to consist of three parts: first, the body of the instrument; second, the optical arrangement; and third, the source of light. We will begin with the lantern body, which in modern instruments is an oblong metal box for enclosing the light: it can be made of tin, thin sheet iron, sheet brass, or other metal. The amateur will probably find tin or brass the easiest to manipulate. Brass looks very well if kept bright and clean; but if the lantern is made of it the inside will have to be japanned. This must also be done if tin is used, and as the latter is rather an unsightly metal, the tin lantern should, to improve its appearance, be japanned outside as well, or else cased in mahogany. As iron is a dark metal it is not necessary to japan it, which is a great advantage, as the japan is constantly peeling off, and must in time be renewed.

The following tools will be required to begin with, and may be purchased anywhere for a few shillings: A boxwood mallet, such as is used by plumbers; a couple of hammers of different size; a punch for making rivet holes—a "French" nail might be used for this purpose, but more than one will be needed, as the point soon gets turned, and the nail is then useless a pair of shears of suitable size, some files, pincers, a set-square, a two-foot rule, compasses; a hatchet-stake or plumber's anvil—a large cold chisel with a rather sharp edge will do instead, but is not nearly so convenient; a soldering "iron," and materials for soldering; a few feet of binding wire; some copper tacks for making rivets and a sheet of whichever metal the amateur prefers to use, about a foot wide and some five feet long. These are the only materials we require at present. We can now begin.

*The Lantern Body.*—First cut out the following pieces, taking care to cut them straight, and without rough edges:—

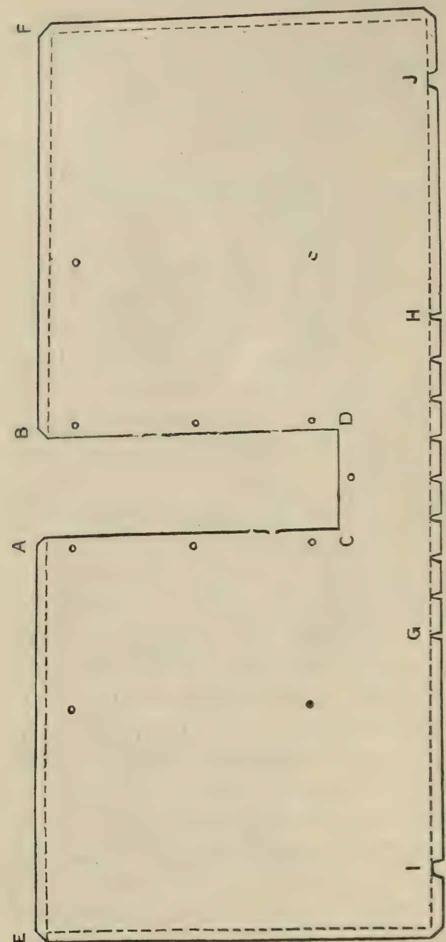


Fig. 3.—Piece for Sides and Top of Lantern (B Piece in Text). Scale, $\frac{1}{4}$ inch to 1 inch.

A, a piece for the bottom of the body, 14$\frac{3}{4}$ inches by 5$\frac{5}{8}$ inches; B, a piece for the sides and top, 19$\frac{3}{4}$ inches by 8$\frac{1}{2}$ inches. There must be an opening cut in the middle of this piece 6$\frac{1}{2}$ inches long by 2$\frac{1}{8}$ inches wide, as shown in Fig. 3, A, B, C, D. (These figures are drawn to a scale of 3 inches to 1 foot.) C, a piece rounded at one end to form a door, as in Fig. 4, 5$\frac{1}{2}$ inches wide by 5$\frac{1}{4}$ inches high;

D, a piece for the front of the lantern, of the same width as the bottom piece ($5\frac{5}{8}$ inches) and $13\frac{9}{16}$ inches long. It is rounded off at one end to match the top of the door, C. About $1\frac{3}{4}$ inch from the rounded end a circular opening must be cut in it for the condenser (see Fig. 5, A). The diameter of the aperture must be about $4\frac{3}{16}$ inches (I am supposing that a 4-inch condenser is to be used. Smaller ones are sometimes recommended, because they are cheaper and lighter; but the 4-inch is the standard size, and,

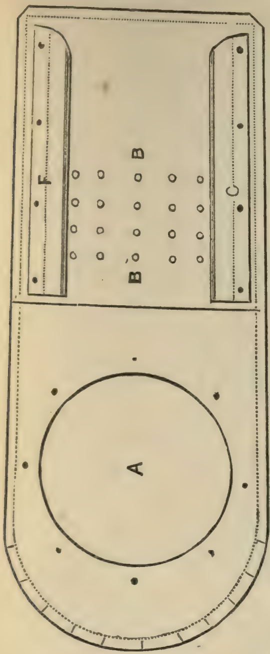


Fig. 5.—Piece for Front of Lantern (D Piece).

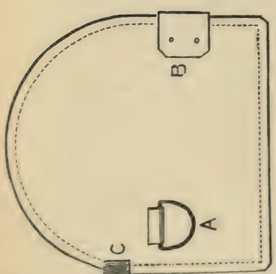


Fig. 4.—Piece for Door (C Piece). Scale, ¼ in. to 1 in.

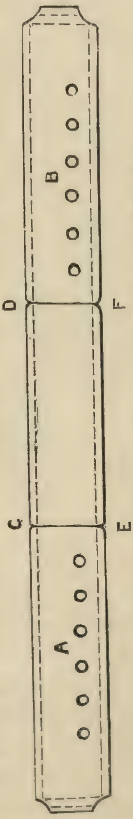


Fig. 6.—Strip for Connecting Front and Bottom (E Piece).

therefore, the best). In this front piece the air-holes, B, B, must also be made at from 3 inches to 5 inches from the straight end; E, a strip for connecting the front, D, with the bottom A, $17\frac{11}{16}$ inches by $1\frac{5}{8}$ inch, with two sets of air-holes (Fig. 6, A, B); F, G, two strips $5\frac{1}{2}$ inches by 1 inch; H, one strip $13\frac{1}{2}$ inches by $1\frac{3}{8}$ inch; I, one strip $14\frac{1}{4}$ inches by $1\frac{1}{2}$ inch; J, K, two strips 8 inches by 4 inches; L, M, two strips $13\frac{3}{4}$ inches by $1\frac{1}{4}$ inch; N, one strip $4\frac{1}{2}$ inches by $\frac{3}{4}$ inch. These

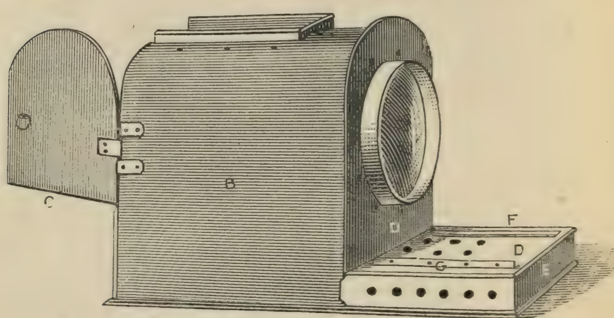


Fig. 7.—Perspective View of Lantern when Finished.

last three strips may be of tin, as they are fixed inside the lantern and are not seen.

The fourteen pieces being cut out, the next thing to do is to flatten them, if necessary, with the mallet, and to file off with a sharp file any roughness or inequality in the edges, after which the holes for the rivets must be made, the inside strips fixed in their places, the edges folded over or turned up, and the top-piece bent into shape. (See Fig. 7, which shows the lantern as it will be when finished. The letters correspond, but the drawing is not to scale.)

Beginning with the bottom-piece, A, the four corners

should first be snipped off, say about $\frac{1}{4}$ inch, then the edges must be turned up all round between $\frac{1}{8}$ inch and $\frac{1}{4}$ inch. The two $13\frac{3}{4}$-inch strips, L, M, are then to be fixed on to the bottom with four or more little rivets; but, first, the outer edge of each strip must be turned up and over, so as to form a groove about a quarter inch deep, and about the same width on each side of the bottom-piece. The grooves are for the lamp to slide in. The distance between the grooves must, of course, be the same throughout ($4\frac{1}{2}$ inches). The other little tin strip, N, has one edge turned over and hammered down to form a smooth edge, and is fixed to one end of the bottom, between the two grooves. It can be fixed in its place either with solder or with rivets. The turned-up end of the bottom-piece being hammered down over it so as to grip the sharp edge, completes that part of the lantern. The rivetting is best done with copper tacks, which should be cut in half, and the head end used. A hole being punched where the rivet is to be, the tack is inserted and the end hammered until a second head is formed.

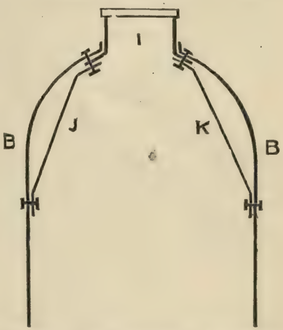

Fig. 8.—Transverse Section of Body of Lantern.

Then cut the corners off the large piece, B, and turn up the edges all round, which is done by placing the piece on the hatchet-stake or cold chisel, and hammering it over it, so as to turn down a strip about a quarter inch wide. Some little practice will be required to make the edge even, which is absolutely necessary if

the different pieces are to fit together nicely afterwards. The edges must be turned up the same way all round.

Hammer down the edges, E, A, B, F, Fig. 3, and make some slight cuts along the opposite edge, between G and H, so that the piece may be bent into the form of an arch, as shown in Figs. 7 and 8, where B, B, are the sides of the lantern (that is to say, the piece we are now at work upon) and I is the base of the chimney. Having bent the bridge into shape, place it on the bottom A, and see how it fits; but do not fasten it on yet, as the I piece has to be fitted into the aperture on top. First cut about three-quarters of an inch off the two opposite corners of the I piece, and fold over the edge along the side between the cut-off corners, then make the two cuts, A, B, Fig. 9, in the opposite edge each about half an inch deep. The cuts are $6\frac{1}{16}$ inches from the end, and the distance between them $2\frac{1}{8}$ inches. Now bend the piece into shape, and spread out the lower edge between the cuts (see Fig. 9), put it into the chimney opening, with the turned-up edge inside. It is, of course, to be rivetted to the top of the lantern; but before it is rivetted, the J, K, pieces are put into the lantern in the position shown in Fig. 8. The edges are slightly bent to make them fit. Rivet holes must be punched through them, and through the spread-out edge of the I piece, and through the top of the lantern, so that the one set of rivets may fix all the pieces in their place. The use of the J, K, pieces is to strengthen the top of the lantern; they are secured at the lower end with a couple more rivets.

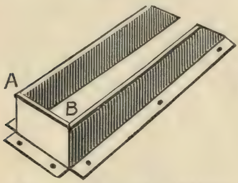


Fig. 9.—Top of Lantern (I Piece).

The top of the lantern can now be fixed on to the bottom-piece. No rivets are required; the bridge-piece is put between the turned-up edge of the bottom, and the edge is turned over and hammered down. A strong, neat, light-tight joint is thus formed with very little trouble. Of course, the back of the bridge-piece must be in a line with the back edge of the bottom-piece.

We must now turn our attention to the front-piece, D, Fig. 5. If the air-holes mentioned before have not yet been made, they must be made now, then the two corners are to be cut off, and the edges turned down. The two little $5\frac{1}{2}$ inch strips, F and G, have one edge turned over and hammered down, and one corner rounded off; they must then be slightly grooved or bent lengthways and rivetted on to the front-piece beside the air-holes, and parallel to the edge of it; they will thus form two grooves $4\frac{1}{4}$ inches apart (see Fig. 5, F, G), extending from about half an inch from the end of the front to near the middle.

The next thing to do is to form the cell or receptacle for the condenser. This is done by fixing the H strip in the circular opening A. We first of all bend over an edge at each end of the strip; one edge should be about one-eighth of an inch, the other about a quarter of an inch, then, placing the two ends together to form a ring, the $\frac{1}{4}$-inch edge is to be turned over the $\frac{1}{8}$-inch edge, and the two are then to be turned down and flattened with a hammer. By this means solder is avoided, but, of course, if brass or tin is used, it would be better to solder it, as soldered joints are neater and stronger. The strip must then be $\frac{1}{4}$-inch shorter, as the ends being placed together nothing is to be allowed for turning over. The diameter of the ring should be

such that it will fit tightly into the opening, A. Having tried it, and found that it fits, we make cuts of equal length (about half an inch), and at equal distances apart, along one edge, and turn out the pieces between the cuts so as to form a flange. We then fix it in its place by means of rivets, as shown in Fig. 7; the cut edges of the flange will not be seen, as they are inside the lantern; the cell projects about an inch from the front; the outer edge should be *slightly* hammered inwards, so that the condenser may be held in its place.

We must next fix the E strip on to the projecting end of the bottom-piece. Having made the air-holes, A, B, Fig. 6, we turn up both edges and bend the strip into shape, first making a cut in the turned-up edge at C, D, E, F, where the bends are to be. The four end corners must be cut out as shown. The best way to make sure of bending it right is to take the centre, and measure from it $2\frac{5}{16}$ inches, or somewhat more than $2\frac{1}{4}$ inches each way, make the cuts there, and bend the two ends towards each other until they are parallel. Now fix it on to the end of the *front*-piece by turning over the edge of the latter and hammering it down, just as we did with the side-piece, B. Bend the front-piece at right angles at a distance of $6\frac{1}{8}$ inches from the turned-up end, or rather, to make sure that you bend it in the right place, lay it beside the lantern, which will show you exactly where the bend should be. All that is now to be done is to cut out a little piece at each side of the B piece, where the strips meet it, as at I, J, Fig. 3. Put the strip and front in position, turn the ends of the strip over the edge of the B piece from the cuts, bend the two ends down, and hammer together to form a smooth joint. Then turn over the

edge of the bottom-piece on to the edge of the strip, and hammer it down; do the same with the edge of the front-piece to fasten it to the bridge, and the lantern body will be so far finished. In hammering down the edge of the front-piece, a hammer or mallet must be held against the opposite side so as to have something to hammer against.

We will now fasten on the door, Fig. 4. First turn up the edge about a quarter of an inch, as shown by the dotted lines, then put it into its place at the back of the lantern to see how it fits. It should go over the edge of the back easily, but not too loosely. A 1 inch brass ring, A, Fig, 4, or a brass knob, is next to be fitted on to one side to serve as a handle. If a ring is used, the best way of fixing it on is to make a slit in the door, flatten a part of the ring, put a strip of metal over the flat part, slip the ends of the strip through the slit, and separate them on the other side of the door; they may then be soldered or rivetted down. The brass knob is usually fixed with a nut. A catch, C, is also advisable, to keep the door shut. A strip of metal inserted in a slit in the turned-up edge of the door, and soldered or rivetted on to it, is bent to form a hook, which is made to catch in a little wedge soldered on to the side of the lantern. To make the hinge, take a piece of sheet brass or other metal about two inches long, and bend it round a piece of wire or a French nail of medium size; this is done by hammering the edge down over it until a tube is formed, which is soldered and cut into three pieces, of which one may be 1 inch wide, and the others ½ inch each. File the edges quite smooth, and fix the inch piece on to the door, and the other pieces on to the lantern, so that the edge of each is in line, one of the ½ inch pieces being above,

and the other below the piece affixed to the door. A piece of wire of the right thickness run into the three tubes, and the ends bent or hammered over to prevent it falling out, completes the hinge, B, Fig. 4. (See also Fig. 7.)

In this lantern the lower half of the back is open to admit a free current of air, as well as to allow of the wicks of the lamp being regulated without opening the door. All who have sat near the lantern at an illustrated lecture, either in a public hall or in a private room, know what a nuisance the frequent opening of the lantern door is, and will realise what an advantage it is not to have to open it until the lecture is over.

## The Slide Stage.

We now come to the slide-stage and lens-tubes, which, in the old form of lantern, were fixed to the front of the instrument by means of thumbscrews, but which, in lanterns of the new form, such as I have been describing, are separate from it. They are now fitted on to a sort of metal bridge or stand, which slides into the grooves, F, G, Fig. 7, and may be placed nearer to or further from the front of the lantern, as is found most convenient. The advantage of the present arrangement is, that the slides are more easily changed; it is better adapted for certain "effect scenes," and it is lighter and simpler. When the stage-holder and lens-tubes are fitted on to the front of the lantern, the lantern itself must be stronger, and even then there is always a chance of its being strained, especially when lengthening tubes are used, as must sometimes be done in very large halls.

This part of the lantern is almost always made of

sheet brass. It may be of the same thickness as that used for the body. First cut out a piece $5\frac{3}{4}$ inches by $5\frac{3}{8}$ inches; this will form the stand or bridge, O, Figs. 10 and 11. A $\frac{1}{8}$-inch edge is turned down all round, and the bridge bent into shape. The sides are $1\frac{1}{8}$ inch wide after the bridge is turned over, and the bridge stands nearly one inch above the grooves when properly bent. It must, of course, be tried in the grooves, and the bend altered, if necessary, until it runs freely in them.

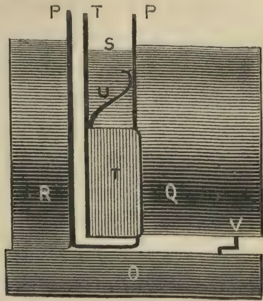


Fig. 10.—Slide Stage and Lens Tube (Side View).

The slide-stage is formed out of a piece $11\frac{1}{2}$ inches long by $5\frac{1}{8}$ inches wide, bent as shown at P, P, Figs. 10 and 11. But before bending it, the two ends must be rounded off, the edges turned over in the usual way, with cuts where the bends will be, and two circular openings cut out, each $3\frac{7}{8}$ inches in diameter.

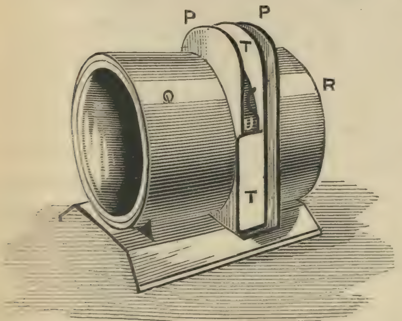


Fig. 11.—Slide Stage and Lens Tube (Perspective View).

We next turn our attention to the tubes, Q, R. The tube, Q, is $3\frac{15}{16}$ inches in diameter and $2\frac{7}{8}$ inches long; the other tube, R, $4\frac{3}{8}$ inches in diameter and $1\frac{3}{8}$ inch long. The former is made of a strip of metal $12\frac{5}{8}$ inches

long, and the latter of a strip $14\frac{3}{16}$ inches long. Begin by filing the ends quite smooth and level; then bend the strips into tubes, or if you have a cylinder or disc of the right diameter, you will find it a good plan to fold the strip, as it were, round it, taking care that the ends meet exactly. Bind it round tightly with wire in three or four places to keep the edges together, and then unite them either with solder or by brazing. In soldering brass, borax is used as a flux. The use of the flux is to keep the edges to be joined bright and unoxidized, and in practice a different flux is used with different metals; thus in soldering tin-plate rosin or a solution of zinc chloride is employed; in soldering lead, rosin or rosin and tallow; and in soldering zinc, which is rather a difficult metal to solder, zinc chloride. The great thing in soldering is to have the edges of the metal to be united clean and smooth and to use as little solder as possible. When the soldering is finished all the superfluous solder should be filed off, so as to make the joining neat and even. Our brass tubes can be joined by brazing, and the *modus operandi* is as follows: First file the edges and about the eighth of an inch of the metal strip until a narrow band of bright metal is obtained, then bend the strip as before described, and fasten it together with iron wire. Put some borax and granulated brass along the inner edge of the tube, and then heat it over a clear bright fire until the granulated brass is melted. When the tube is cold it will be found to be so strongly and neatly joined, that the seam itself is scarcely to be distinguished from the surrounding metal. The tubes may now be fastened on to the slide-stage piece over the openings. If they are not perfectly cylindrical, or if there are dents in them, they

must first be pressed into shape, and the dents carefully hammered out. When they have been placed exactly in position, one over each aperture, and both on the same side of the stage-piece, drop a few drops of solder along the edge to keep them in their place while you are soldering them on.

Two more pieces, S, T, must now be cut out. The first is a strip $11\frac{7}{8}$ inches by $1\frac{1}{2}$ inch, bent into a ring or tube, which will slide easily into the tube, Q. The T-piece is $7\frac{1}{2}$ inches by 5 inches. One side is rounded to correspond with the top of the slide-stage,

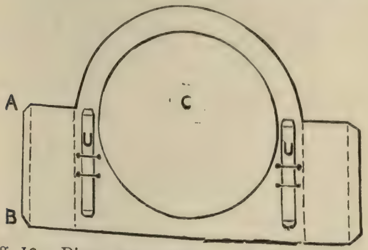


Fig. 12.—Piece to carry Lens Tube (T-Piece).

the other side is cut into the shape shown in Fig. 12, the length of the flaps is $1\frac{1}{4}$ inch, width (from A to B) $2\frac{1}{4}$ inches. The circular opening, C, is cut out in the centre of the piece, and the tube, S, soldered round it. The little bow-shaped springs, U, U, are then fastened on to the T-piece, between the tube and the flaps, the tube, S, is put into the tube Q, the flaps are turned down, and about a quarter of an inch of the end of the flaps is turned over the front of the slide-stage, to prevent the springs from pushing the piece out of its place. The object of this spring-piece is to keep the slide-holder (to be described later on) pressed against the other side of the stage.

Two little pieces of a clock spring about a quarter of an inch wide will do for the springs, and they may be fastened in their places either with a couple of wires passing through the holes in the T-piece, and twisted over them, or with a strip of tin or brass soldered over each to form a band. The ends of the springs, if not turned up, must be "tipped" with a little bit of brass in order to prevent them from catching in the side of the stage. The diameter of the aperture, C, should be somewhat less than that of the tube S. The last thing to be done is to bend the slide-stage piece into shape (the space between the sides being $1\frac{1}{8}$ inch), and solder it and the tube, R, on to the bridge, O. The other tube, A, must have a support under it, V. This support must be cut out to let the tube lie in it. It is then soldered on to the bridge-piece, and the tube soldered on to it.

This part of the lantern is now complete; but, as I mentioned before, if made of tin or brass the body will have to be japanned. The outside of the lens-tubes and the slide-stage is generally left bright, but the whole of the inner surface will have to be japanned, and this had best be done before we go any further

## CHAPTER II.

### *THE CONDENSER—THE OBJECTIVE—THE LAMP.*

WE must now turn our attention to the lenses: these consist of a condenser and an objective.

### The Condenser.

*The Condenser* may be single, double, or triple. It is inserted in the lantern front between the source of light and the slide, and is used for the purpose of collecting or "picking up" the rays of light, and transmitting them through the slide to the objective. The common "bull's eye," or plano-convex lens, is the simplest form of condenser, but it is never used in any but the cheapest toy lanterns; a somewhat better condenser is the single bi-convex lens. This is the lens generally used in toy lanterns. It varies in size from about $1\frac{1}{2}$ to 3 inches in diameter, and it should have a focal length of from about $2\frac{1}{2}$ to 3 inches. Neither of these simple or single lens condensers will do for our lantern. We require a combination of two lenses, or a double condenser, as it is called. Various combinations have been tried, and it is still a question which is the best. When a lamp is used to form the source of light, a combination of two bi-convex lenses may be employed;

but a condenser of this description is not suited to, what I may call, a pointed light, such as the lime light or the electric light. The combination generally used in the phantasmagoria lantern was first recommended, I believe, by Sir John Herschel many years ago, and consists of a meniscus, A, Fig. 13, and a bi-convex, B, turned as shown in the figure. It is put into the lantern with the meniscus towards the light. This condenser will do for our lantern, or we may use a combination of two plano-convex lenses, mounted with the convex sides together, as in Fig. 14. This is the condenser now generally supplied with the new lanterns.

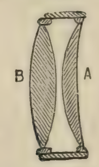


Fig. 13.—Double Condenser of a Meniscus Lens (A), and a Bi-Convex Lens (B).

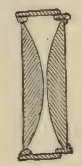

Fig. 14.—Another Double Condenser of two Plano-Convex Lenses.

The standard condenser is the four-inch, which, as I said before, is the one we had better use in our lantern. Many exhibitors use a larger size, but we should not gain much by doing so. The four-inch one is quite large enough for our requirements, and of course a large condenser would be much more expensive. Condensers of the standard size can be had ready mounted in brass cells at most opticians' for about a guinea, and the amateur will find it better to buy them than to grind the lenses himself. The grinding of lenses is a tedious and troublesome undertaking. I may mention that it is not as essential to have first-class condensers as it is to have first-class objectives. Marks, such as scratches or *striæ*, on the condenser are not of much

consequence. In mounting lenses in the holder or cell, care should be taken to mount them loosely. Many lenses have been cracked by being mounted too tightly. Condenser lenses especially must be loose in the cell to allow for the expansion and contraction of the latter when the lamp is lighted or extinguished. The exhibitor should always have a spare condenser, or at any rate a spare lens, with him when he goes out to give an entertainment, so that if, as sometimes happens, even when due precautions are taken, one of his lenses gets cracked he can replace it, and avoid having either to postpone his exhibition or to show his pictures with the dark mark, caused by the broken glass, across the screen.

Triple condensers have not come into general use, though they possess some advantages over the double ones. The object in introducing a third lens is to shorten the focus of the condenser, the advantage of which is that it can be brought nearer to the light and will then pick up more of the rays. One of the triple combinations is that of three plano-convex lenses, two of which are mounted close together with the convex side turned inwards, as in Fig. 14, while the third, which may be a smaller lens, is placed between them and the light. The flat side of this third lens is towards the light. Another triple combination is that of a meniscus and a bi-convex mounted together, as in Fig. 13, and a plano-convex in front. As the amateur is not likely to use a triple condenser I need not enter into any further particulars on its construction.

## The Objective.

*The Objective* magnifies the image of the picture, and projects it on to the screen. Everything, I may say,

depends upon the objective, and if it is not a good achromatic combination of lenses we shall not obtain anything like satisfactory results.

The simplest objective is the single bi-convex lens, which may be used in one of the small toy lanterns, but will not do for any of the better class instruments. A single plano-convex lens forms another cheap objective suitable for toy lanterns. It should have a diaphragm in front, to correct as much as possible the defect known as spherical aberration, about which I shall have a few words to say further on. The diaphragm is an opaque disc, made of either cardboard or metal and blackened

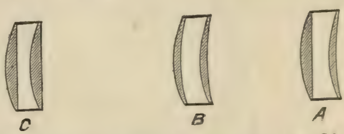


Fig. 15.—Different Combinations for the Objective.

on both sides. It has a circular opening in the centre to allow the inner rays of light to pass through, all the outer rays being cut off by the opaque part of the diaphragm. In all the best lanterns an achromatic combination of lenses is used. The objective that was generally supplied with the phantasmagoria lantern was a combination of a plano-convex lens and a meniscus, Fig. 15, A, the convex side of the former being turned towards the light and the concave side of the latter outwards, or a combination of two meniscus lenses mounted as shown at B in Fig. 15. Another combination is that of two bi-convex lenses or two plano-convex lenses, C, Fig. 15.

In all good lenses the defects of chromatic aberration and spherical aberration have to be corrected. To understand how this is done it is necessary to explain

what these defects are, and how they are caused. If an ordinary non-achromatic lens or combination of lenses, such as A, B, or C, Fig. 15, is put into the lens-tube of the lantern, the disc projected by it on to the screen, instead of being white all over, will have a coloured band or rather a series of coloured circles along the edge. This is the defect of chromatic aberration, and it is caused by the splitting up of the coloured rays of which white light is composed. All those who know anything about light must know that white light is built up or composed of the seven colours of the spectrum ranging from violet on the one side to red on the other. The rays of light in passing from a rare medium, such

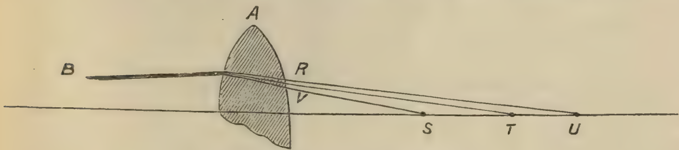


Fig. 16.—Chromatic Aberration.

as air, into a dense medium, such as glass, are turned aside or bent from the straight course; in other words they are refracted. But as some of the rays are more refracted than others, it follows that the beam of light will be split up. The rays which are most bent are those at the violet end of the spectrum, and they of course will come to a focus at a point somewhat nearer to the centre of the lens than the rays at the other end of the spectrum, which being less refracted pursue a straighter course. Fig. 16, in which the defect is of course greatly exaggerated, will make this clearer. A is the lens, B a beam of light, which in passing through the lens becomes split up into the coloured rays R, V. Some of these rays come to a focus at the point S, others

at T, others at U, the result being that pictures shown with a lens of this description will have a rainbow-tinted band along the edge. Now it is evident that if we can cause the rays to recombine and to leave the lens as a single beam of white light we shall correct the defect. This is what is done in the achromatic lens. It was found that if a convex lens made of crown glass was combined with a divergent or concave lens made of flint glass the one would correct the other. A convergent lens of crown glass is therefore cemented to a divergent one of flint glass as shown in Fig. 17; and, as will be seen, the ray of light which is split up in the former is reunited in the latter, and leaves the

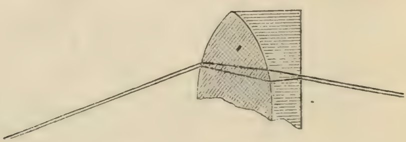

Fig. 17.—The Achromatic Lens.

combination as a single white ray. The achromatic lens is a combination of two or more lenses of crown and flint glass cemented together with Canada balsam.

Spherical aberration is not so serious a defect as the one I have just described. The defect is shown by the blurring of the image on the screen, and it may be corrected to a certain extent by cutting off the outer rays by means of a diaphragm or stop as I explained before. The cause of spherical aberration is the curvature of the lens, which refracts the marginal rays more than the inner ones, thus bringing them to a focus at different distances from the centre of the lens. The result of this is, that a sharp picture cannot be obtained on a

flat screen. When the picture is focused to be sharp and distinct in the centre, the outer portion will be more or less blurred or confused, and if it is focused to be sharp along the margin the centre will be confused and indistinct. By intercepting the outer rays we can focus so as to obtain a fairly flat field; and the more of these outer rays we cut off, in other words, the smaller the aperture in the stop, the more equal will the picture be in sharpness. The aperture in the stop must not be too small, however, because of the great loss of light. Indeed, it is absolutely necessary to get all the light we can, more especially when we are working with a lamp or other comparatively feeble light. A small stop—that is, a stop with a small aperture—cannot then be used, and the defect must be corrected in some other way. This is done by properly combining a convergent lens with a divergent one. The convergent lens is a lens which causes the rays to converge or come to a point, and the divergent lens is one which causes them to diverge or spread out. Convex lenses are convergent, and concave lenses are divergent. In correcting for spherical aberration it is therefore necessary to combine a convex lens with a concave one. The action of the meniscus lens is, as it were, first to separate the rays and then to make them converge. That the rays must sooner or later combine when sent through a meniscus lens, is certain, if the curve of the lens is greater on the convex than on the concave side. Having now explained the cause of and means of correcting these two defects, it is only necessary to add that when an objective is corrected for chromatic aberration it is said to be *achromatic*, and when corrected for spherical aberration it is said to be *aplanatic*.

A good photographic portrait lens will make a first-rate objective for our lantern, and if the amateur has one by him, all that he need do is to fix the screw-ring belonging to it into the end of a brass tube of suitable size and fit the latter into the lens-tube already described. A serviceable objective can be constructed with two plano-convex lenses turned the same way; each lens must be an achromatic combination of a crown glass lens cemented to a plano-concave lens of flint glass. Such a combination is shown in Fig. 18.

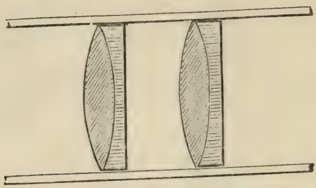

Fig. 18.—The Achromatic Combination Lens.

## The Lamp.

As I mentioned before, mineral oil lamps have to a great extent taken the place of the old oil lamp. In most of the toy lanterns now made a small flat wick petroleum lamp is used, a reflector being placed behind the flame to throw the light on to the condenser. In the phantasmagoria lantern a solar Argand lamp was formerly used, but is now superseded by the new three or four-wick mineral oil lamps. No doubt the Argand lamps were good enough when the lantern was used in a private room and only a small disc was required. The light was not unsteady, and, practically speaking, no unpleasant fumes were given off while the lamp was in use. The great objection to the present mineral oil lamps lies in the smell, which is

often very strong, especially when they are not properly managed.

Fig. 19 shows a three-wick mineral oil lamp such as we shall require for our lantern. It is shown with the dome or top raised, and the doors open. A is the reservoir, $6\frac{1}{2}$ inches long by 4 inches wide by $1\frac{1}{2}$ inch deep; B, the dome, $6\frac{1}{8}$ inches long by 4 inches wide by $3\frac{1}{2}$ inches high. One end of the dome is closed by a piece of glass let into a frame, and the other end by a reflector, C, also inserted in a frame. E E is a frame or support for the dome to rest on, and to the front of which it is hinged. The three wick-holders, and the rods for regulating the wicks, are more clearly shown in Fig. 20.

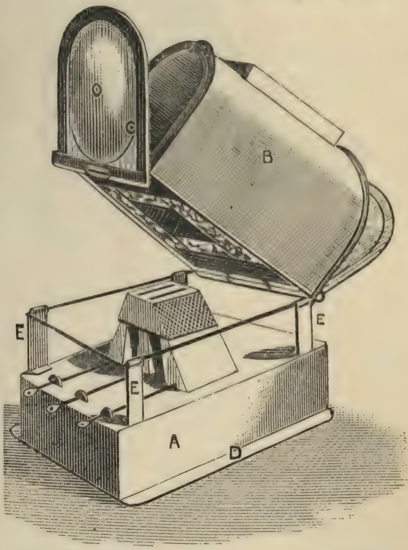


Fig. 19.—Triplex Lamp with Dome Raised.

The first thing to make is the reservoir, usually constructed of tin. First cut out a piece of tin (or other sheet metal) 10 inches by $7\frac{1}{2}$ inches, then cut out the corners as shown in Fig. 21, the three apertures for the wick-holders, A, B, C, and the circular opening, D, which is intended for filling the reservoir. The three apertures, A, B, C, are each $1\frac{5}{8}$ inch by $\frac{9}{16}$ inch;

they are cut out parallel with one another, but it must be noted that the centre one, B, is not in the

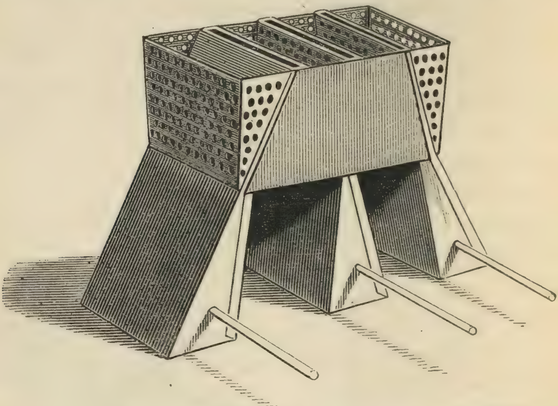

Fig. 20.—Wick-Holders, and Rods for Regulating Wick.

exact centre of the reservoir. The space between A and B is 1 inch, and that between B and C $\frac{3}{4}$ inch. The

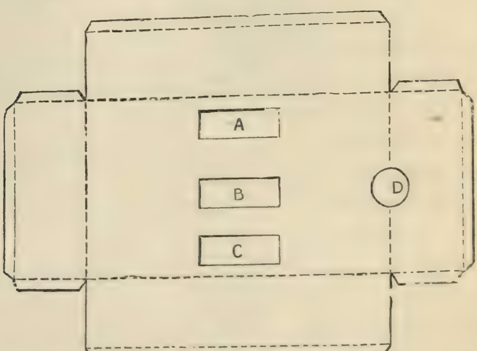


Fig. 21.—Plan of Reservoir with Apertures for Wick-Holders.

diameter of the circular opening may be $\frac{3}{4}$ inch, or more or less. Now bend down the edges of the side

and end pieces where the dotted lines are, cut off all the points, and form the piece into an oblong box about $6\frac{1}{2}$ inches long by 4 inches wide, and solder the corners together. Cut out a piece for the bottom rather less than $6\frac{1}{2}$ inches by 4 inches, but do not solder it on until you have made and fixed the wick-holders in their place.

The wick-holders are formed of two pieces of tin each; three of these pieces are $2\frac{11}{16}$ inches by $1\frac{7}{8}$ inch, and the other three are $2\frac{11}{16}$ inches by $2_{5}$ inches (see A and B, Fig. 22). The B pieces are of the same width at top as the A pieces, but at a distance of $1\frac{1}{8}$ inch from one end they widen gradually to $2\frac{9}{16}$ inches. Make the cuts shown in the figure, and turn up the sides at the dotted lines to form shallow troughs $1_{5}$ inch wide. The A pieces should be bent into somewhat wider troughs than the others, so that they may fit over them. Now get six little cog-wheels, and three pieces of stout wire to serve as rods for turning the cog-wheels. Put a bit of $1\frac{1}{2}$ inch wick into the B troughs, arrange the wires and cog-wheels over the wick, and make a mark exactly where the wires are to pass through the sides of the trough, and then make the holes shown in the figure; they should be exactly the size of the wires. This done, put the wires through the first holes; fix two cog-wheels on to each wire about $\frac{3}{4}$ inch apart, put the end of the wires through the second holes and fix a couple of little metal washers on to the wires to keep them in their place. Try how they work with the wick, and if they work well, bend the other troughs

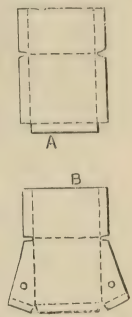

Fig. 22.—Two Pieces for the Wick-Holders.

slightly where the side cuts are until they exactly fit, then solder them on, and, lastly, fit them over the apertures in the top of the reservoir and solder them down. They are turned with the rods to the back of the lamp (the end of the reservoir opposite to that with the circular opening). Three little bits of brass about $\frac{3}{4}$ inch long, rounded at one end, and with an edge turned over at the other end, will make holders for the rods, as shown in Fig. 19. They are soldered on to the top of the reservoir near the back. Finally, three small brass knobs should be soldered on to the end of the rods to serve as handles. The length of the rods may be $4\frac{3}{4}$ inches, and the diameter of the little cog-wheels about $\frac{1}{4}$ inch.

The three wick-holders must be connected at the upper end by means of two little pieces of tin (about 1 inch wide) soldered on at back and in front. Two small troughs are also to be soldered between the holders. They may be made of two pieces of perforated tin, $1\frac{1}{2}$ inch square, bent into the shape of a U. Two other similar troughs are soldered on outside the two outer holders, as shown in the figure. They are about the same width as the holders, and about $1\frac{1}{4}$ inch deep.

The bottom piece can now be soldered on to the reservoir, and a brass ring of any convenient diameter (say 1 inch) affixed to the back of the lamp by means of a strip of brass or tin passed through it and soldered on to the bottom. This ring is for pulling the lamp out of the lantern, for which purpose the rods should never be used. Two strips of tin rather shorter than the reservoir, and about $\frac{3}{4}$ inch wide, must then be soldered to the bottom, one at each side, to form the two tongues to run in the grooves in the lantern

body: they may be rounded off at the corners, and should project about $\frac{1}{4}$ inch from the bottom of the lamp.

The support or frame (E, E, E, Fig. 19) is made of a piece of stout wire (galvanized iron wire is the best), and four, six, or eight pieces of block tin or brass $2\frac{1}{8}$ inches long and about 1 inch wide. First bend the wire into an oblong frame of the same width as the reservoir, and $5\frac{5}{8}$ inches in length, then turn down $\frac{1}{8}$ inch at one end of the strips, and about $\frac{1}{4}$ inch at the other end; put a strip at each corner of the frame (and if you have cut out six, one about the middle of each side), and hammer the $\frac{1}{4}$ inch edge over the wire to secure the strips to the frame, or solder them down; then turn the frame over, and, if necessary, bend it and the strips into shape; put it on the reservoir, and solder the other ends of the strips down to it.

The top of the lamp is generally made of sheet iron. First, cut out a piece 10 inches by $6\frac{1}{4}$ inches, turn down an edge on the two sides about $\frac{1}{4}$ inch, and cut out the aperture for the chimney ($3\frac{1}{2}$ inches by $1\frac{1}{2}$ inch). Now fix a piece round this aperture to form a base or support for the chimney. This second piece should be about $10\frac{1}{2}$ inches long by $1\frac{1}{2}$ inch wide. Bend it into a frame the same size as the aperture (or rather a trifle smaller, since it is to fit inside it). About $\frac{1}{2}$ inch will overlap at the end, which will enable you to join it together with a couple of little rivets. Then make cuts $\frac{1}{2}$ inch long at the four corners, and turn out the edges; put it into the aperture and rivet it on to the top piece, the turned-out edges to be inside the dome when the latter is bent into shape, which can now be done. To keep

the dome in shape, a wire frame similar to the one we made for the stand, E E, must be fixed on to it. This second frame must be of the same width as the other, but $\frac{5}{8}$ inch longer. When you have formed the frame you must join the ends, which you can do by filing the ends smooth, putting a little borax, made into a paste with water, on to them, and winding some brass wire round them. If you now put some more wet borax over the brass wire, and heat the frame over a clear fire, the brass will soon melt, and running into the joint, will unite the ends very securely. The frame has now to be turned down at the four corners in such a manner that the two ends may fit over the front and back of the lower frame, E E. The best way to bend the wire is by using two pairs of tweezers, with one of which you hold the wire close to where the bend is to be, and with the other you make the bend. About $\frac{1}{4}$ inch should be turned down. The frame is now ready to be fixed on to the lower edge of the top piece; and this is done by turning up about $\frac{1}{4}$ inch of the edge, and hammering it down over the wire. The next thing to do is to cut out two little pieces of sheet iron $3\frac{11}{16}$ inches by $2\frac{3}{4}$ inches (A, Fig. 23), to be fitted inside the dome, and two pieces $3\frac{1}{2}$ inches long by $1\frac{3}{8}$ inch wide; which last, when bent into the shape shown at B, Fig. 23, are rivetted on to the first two pieces, and form a sort of burner (see Fig. 24). The width of the opening between these two side-pieces is $\frac{15}{16}$ inch, and it is 2 inches long from A to A. The two side

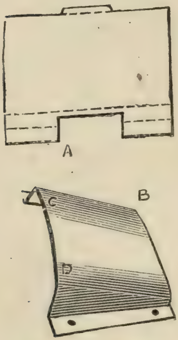

Fig. 23.—Burner.

pieces are joined to the end-pieces with rivets, and the whole forms a kind of bridge. The opening is about $1\frac{1}{4}$ inch from the bottom of the dome, and the top of the little side-pieces is $\frac{1}{2}$ inch above the top of the wick-holders. A piece of fine perforated tin $3\frac{11}{16}$ inches square, with an aperture $2\frac{1}{8}$ inches by $1\frac{3}{8}$ inch in the middle, is rivetted on to the other end-pieces, as shown in Fig. 19.

The frames for the front and back of the dome are made of thin sheet copper, as copper is the most malleable metal we can use. The two frames are similar in size and construction, so that only one need be described; but the strips required for both can be cut out at once. Two strips of copper are all we want (for each frame); one $4\frac{1}{16}$ inches by $\frac{3}{8}$ inch, to form the lower groove, and the other 10 inches by $\frac{3}{8}$ inch to form the two sides and the rounded top. The first or bottom piece, being straight, is easily made into a groove about $\frac{1}{4}$ inch deep and $\frac{1}{8}$ inch wide; the other piece is much more difficult to form. It must be hammered over a metal or hard wood disc of the shape of the top of the lamp. With a suitable disc and some care and patience a neat groove can be formed without a "wrinkle" or inequality anywhere. The two ends of the upper groove rest in the lower one, which must be slightly widened at the corners to let them in. A rivet is used to join them

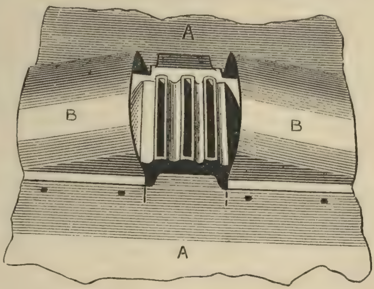

Fig. 24.—Enlarged View of Burner, Showing How it is Fitted.

at one corner; but as it is often necessary to open the frames, it would be inconvenient to rivet them at both corners. A little bit of copper wire put into a rivet hole, and the ends turned down, will answer all the purpose.

The lower groove is hinged on to the end of the wire frame, and a catch formed of a strip of metal about $\frac{1}{2}$ inch wide and 2 inches long, bent back on itself to act as a spring, and rivetted on to the top of the dome, keeps the frame shut. The hinge is made of a strip of brass about $1\frac{1}{2}$ inch long, and 1 inch wide. One side is bent into the shape of a U for the bottom of the frame to rest in, the other side is hammered over a piece of wire, or a "French" nail, of the same thickness as the wire of which the frames have been made: thus a little tube is formed at one end of the U. This tube is sprung over the wire of the dome-frame, and secured with solder; the frame being put into the U and soldered to it, the hinge is complete. The two ends of the bridge-pieces, Fig. 24, are turned over the wire frame on either side of the hinge, to finish off this part of the lamp.

The reflector is made of copper, and plated. It is hammered into shape from a piece of sheet metal about 4 inches square. The concavity given to it is not of very much importance, practically speaking, but it is very necessary to avoid all inequalities, such as ridges or dents in its surface. A hole about $\frac{1}{2}$ inch in diameter may be made in the exact centre of the reflector to enable the operator to look into the lamp from time to time when in use, for the purpose of regulating the wicks. This hole being directly behind the wicks, or rather the flames, will not in any way interfere with the working of the reflector. About a

quarter of an inch of the reflector is left flat, and a small piece is cut off the bottom and sides to let it fit into the grooves. Of course, only the front (concave side) of the reflector requires to be plated. As a rough and ready means of determining the concavity I may mention that the centre should be sunk about $\frac{7}{16}$ inch below the sides.

Cut out a piece of glass to form a window for the front frame, and a piece of talc to put in front of the reflector in the back frame; then get a short length of brass tubing, fitted with a screw-cap, and solder it in the hole in front of the reservoir; and lastly, hinge the dome on to the support in front. The hinge is made of a piece of brass or copper, $3\frac{1}{2}$ inches by 1 inch, one side is turned over a wire to form a tube, which is then sprung over the wire of the support and soldered; the other side is rivetted to the lower part of the bridge.

We have now only to make the chimney, which is easily done. You can use sheet iron, tin, brass, or copper for it, and you must cut out three pieces, two for the chimney itself, and one for the top, as it is made on the telescopic principle for convenience in packing, and one of the tubes must be somewhat smaller than the other to slide within it. The lower tube fits on to the top of the dome, and slides within the upper one. They are both 5 inches long, and the upper one is $3\frac{5}{8}$ inches by $1\frac{5}{8}$ inch in width. You should cut out a piece $11\frac{1}{4}$ inches by $5\frac{1}{4}$ inches for it, which will allow an edge to be turned down at top and bottom, and leave about $\frac{3}{4}$ inch to overlap at the side. The other piece may be about $\frac{3}{8}$ inch shorter. An edge should be turned over at the lower end of the smaller tube, and at the upper end you must make two $\frac{1}{2}$ inch cuts at each side about $1\frac{3}{4}$ inch apart, and

bend out the piece between the cuts so as to form a sort of catch on each side of the tube. At about $\frac{1}{2}$ inch from the lower end of the upper tube you make a groove or indentation about 2 inches long on either side of the tube for the two catches, which thus keep the upper tube in its place, as shown in Fig. 25. The top is a piece of the same metal, $7\frac{1}{4}$ inches long by $2\frac{3}{4}$ inches wide in the middle, tapering to $1\frac{1}{2}$ inch at the

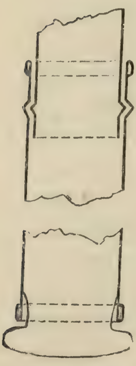

Fig. 25.—Section of Chimney.

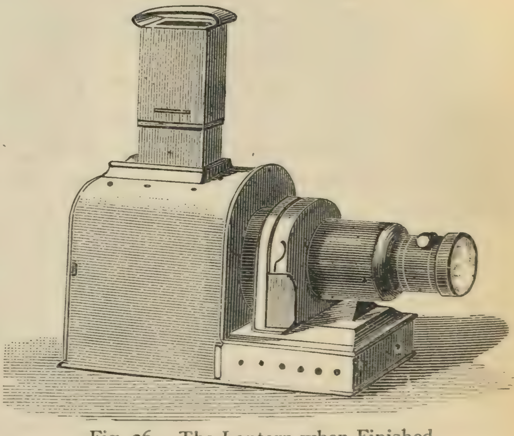

Fig. 26.—The Lantern when Finished.

two ends. It is fixed on to the upper tube with two rivets at each end. Our lamp is now ready for use. Fig. 26 shows the finished lantern.

Thus far, then, have we proceeded together in its construction, and the result is an instrument which, if tolerably inexpensive to make, would be dear to buy. If the parts have been properly put together it will be suitable for every purpose for which a lantern of this kind may be required.

# CHAPTER III.

*HOW TO USE THE LAMP—THE SLIDE-HOLDER—THE SCREEN—THE SCREEN STAND—THE LANTERN STAND—THE READING LAMP—PARAFFIN MEASURE—THE LANTERN BOX—DISSOLVING VIEWS.*

WHEN you want to use your lantern, you should warm and carefully wipe the lenses of the condenser and objective; put the former into the holder in the front of the lantern, screw the latter into the ring in the front tube, and slide the slide-stage into the grooves on the lantern front, pushing it "home." Then open your lamp, and put a piece of $1\frac{1}{2}$ inch lamp wick into each holder, cut the edge of each wick perfectly straight and even, see that they work freely up and down in the holders, and partly fill the reservoir with the best paraffin. You should use only the *best* paraffin, and never fill the reservoir more than two-thirds. As soon as the wicks are thoroughly soaked, light them, turn them down low, and close the lamp. Draw out the chimney to its full length and put it on, then slide the lamp in the grooves in the bottom of the lantern, and begin turning up the wicks; they must be turned up equally, and little by little, so as to heat the front glass gradually. If they are turned up suddenly the glass is very likely to break, and, what would be far worse,

you might crack the lens of your condenser. After a minute or two, however, you can safely turn them up to their full height. The maximum light is obtained by turning them up until they are on the point of smoking. It is a good plan to turn them up until they begin to smoke, then turn them down very gradually until they cease to smoke. The smoke is seen issuing from the top of the chimney.

Stand the lantern on a high steady table, and turn it towards a white wall if you have one ; if not, you must hang up a sheet or tablecloth to form a screen, taking care to hang it so as to avoid all folds or creases, which would cause unsightly shadows in the picture and distort it. Now focus the disc by turning the focusing screw on the objective lens, and when the edge of the disc is quite sharp and equally illuminated in every part, you can put in your slide-holder and the slides you intend to show one after another. If a shadow appears on the upper or lower half of the disc, it is probably owing to the lamp having been pushed into the lantern a little too far or not far enough, and, of course, you get rid of the shadow by moving the lamp one way or the other. Sometimes, however, the mark is due to damp on the condenser : in this case it will fade away in a few minutes when the condenser gets dry.

The lamp used with the old phantasmagoria lantern is an Argand Fountain oil-lamp. The best oil to burn in it is that known as camphorated sperm, which the amateur can prepare in the following manner. From one to two ounces of camphor should be allowed for every pint of sperm oil. The camphor must first be cut up into small pieces ; then the oil should be put to heat, and while it is heating the camphor can be dropped into it and the oil stirred until it is melted. The object

of adding the camphor is to increase the illuminating power of the oil.

The lamp is filled by taking the inner chamber out of the reservoir at the back of the lamp, inverting it, and filling it with the camphorated oil, which should be previously warmed. The valve in the top (or rather bottom, since it is turned upside down) of this chamber is then closed by pulling up the plug, and the chamber is again inverted and replaced in the reservoir. But before this is done a new wick should be put into the wick-holder. A small conical stick of the same diameter at the larger end as the wick is used for this purpose, the wick being sprung over it and the end of the stick inserted in the holder. The wick can then be pushed off the stick and on to the holder. The wick must be allowed to become thoroughly saturated with oil before it is lighted, and for this the lamp should be filled at least a quarter of an hour before it is wanted. Turning the flange of the lamp raises or lowers the wick, which should be turned down as low as possible previous to being lighted. It must be carefully trimmed with sharp scissors, and should be turned up gradually after it is lighted, so as to heat the chimney slowly. The reflector should be polished with *rouge* and a chamois leather before it is used.

## The Slide-Holder.

If our lantern works satisfactorily, we can next turn our attention to the principal accessories.

The first and most indispensable of these is—

*The Slide-Holder* or carrier mentioned above. A good many different carriers have been used, most of which answer their purpose well enough. The one I am about to describe has the advantage over many others

of being easily made, light, and handy. The object of the carrier is not merely to hold the slides (as many people suppose), but also to enable you to put them exactly in the right position in the slide-stage. Without a good carrier one slide might be pushed in too far, another not far enough; and, in fact, every slide would have to be adjusted in the lantern, which, besides being a great waste of time, is most disagreeable to the spectators. When dissolving-views are shown, half the effect is lost if the slides do not appear exactly in the right position on the screen.

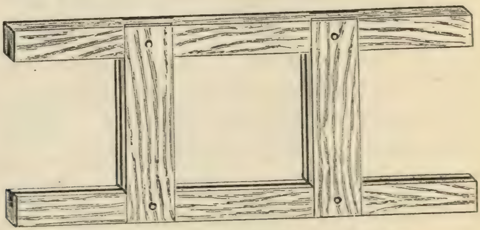

Fig. 27.—The Slide-Holder or Carrier.

Fig. 27 shows the carrier for the ordinary $3\frac{1}{4}$ inches by $3\frac{1}{4}$ inches slides. It is $9\frac{3}{4}$ inches long by $4\frac{1}{4}$ inches wide, and the aperture of the frame is $2\frac{7}{8}$ inches square. It is made of mahogany or other hard wood, of which you must cut out six pieces, two for the top and bottom and four for the sides. The former are $\frac{1}{2}$ inch thick and $\frac{11}{16}$ inch wide, the latter are thin strips about $\frac{1}{8}$ inch thick and 1 inch wide. As shown in the figure, the four side-pieces are let into the top and bottom pieces, so as to leave an aperture between them for the admission of the slides. The top and bottom pieces are grooved to a depth of somewhat over $\frac{3}{16}$ inch, the width of the groove corresponding to the width of the

opening between the side-pieces, or about $\frac{1}{4}$ inch. Of course the two grooves must be quite smooth for the slides to run in. The carrier is inserted in the slide-stage and kept in its place by the spring-plate; the slides are then pushed into the carrier on the right-hand side and withdrawn on the left. You begin by putting the first slide into the grooves, then you push it into its exact position in the frame by means of the second slide, which you push in after it until its outer side is in a line with the ends of the holder; then when you want to show the second slide you put the third into the grooves and push the second into the place of the first, which is pushed to the other end of the holder, where it can easily be removed. Thus your slides will always be exactly centred, and each one ought to be in focus after you have focused the first.

When you first put the carrier into the stage aperture, you will have to see that you get the frame in the centre of the lens tubes, but if you then make a mark on it, or nail a little bit of wood to the bottom to form a stop, you will have no difficulty in putting it back again in the right place on a future occasion. I may as well mention here that the slides must be put into the carrier *upside down*, and the black side of the mount is generally turned outwards, but this, of course, depends upon how the slides are mounted. Sometimes plain black mounts are used, in which case it is not very easy to tell which is the right or film side of the picture or photograph, and the slide is very likely to be put in wrong, which, though not always of much consequence, would in certain cases be very inconvenient, as, for instance, if a map of the British Isles were shown in reversed order, *i.e.*, with Ireland on the right or east side of England.

## THE SCREEN.

*The Screen* must next claim our attention. There are transparent screens and opaque screens. When a transparent screen is used, the lantern is placed behind it, and the pictures are shown through. It is generally much more convenient to have the lantern away from the spectators, and the effect of the sudden appearance of the pictures on the screen is more startling when the lantern is not seen. But there are two disadvantages attending the use of transparent screens—one is the amount of space that is lost behind the screen, which if the room in which the entertainment is given is small, is a matter of no little importance; the other is the glare that is always seen more or less in the centre of the disc, and though it is reduced to a minimum by wetting the screen, yet it cannot be altogether got rid of. Again, the necessity of wetting the screen is another drawback, especially if it is to be hung up in a drawing-room. In addition to these disadvantages there remains the fact that the pictures are never quite so clear when shown through a screen as when shown on an opaque surface.

A transparent screen can be made of muslin; but it is better to make it of thin cotton sheeting or some semi-transparent material, because it can then be used as an opaque screen should the necessity for doing so arise. If the exhibitor is satisfied with a small screen, say 9 or 10 feet square, he can get some cotton sheeting of that width, but if he wants a larger screen he will have to join two or more widths. The seam ought to be as narrow and neat as possible, and should be in the lower part of the screen, which, unless it is very large, can easily be managed. A broad tape

should be sewn round the edge of the screen in which eyelet-holes can be worked. These eyelet-holes are for stretching it to the stand, to be presently described. The screen should be hung up dry; the simplest way of wetting it is with an ordinary garden syringe. It should be syringed equally all over, but it need not be made too wet, and of course it must not be syringed too long before the commencement of the entertainment.

Nothing makes so good an opaque screen as a plain white wall, but, unfortunately, nowadays, this is very seldom available. A very good screen can be made by pasting large sheets of white paper on to fine canvas or linen. When quite dry, it can be mounted on a roller of suitable size. Of course, a screen of this sort might be made of almost any size, but it would be very awkward to carry about if more than 10 or 12 feet square, and it cannot be folded up. It shows off the pictures very well, however, is always ready for use, and is put up without a frame. It has this great advantage over linen and cotton screens, that a slight current of air does not affect it, whereas the latter are swayed by the slightest draught. It is a good plan to make a 10-feet paper screen for use in ordinary rooms, and to have besides a 15-feet linen screen for use as a transparent or opaque screen in schoolrooms or other places where a large screen can be put up. Screens of 20 feet, 25 feet, and even 30 feet, are used by professional lecturers, but the amateur is not likely to require one more than 15 feet, or at the most 18 feet square. Nor is it at all advisable to show the pictures on too large a scale. Small bright pictures are always more pleasing and effective than large dull ones. The size of the pictures depends upon the distance the lantern is from the screen; and, in deciding

on the size to show them, we should not forget that "light decreases inversely as the square of the distance." Slides vary so much that it is impossible to say to what extent they should be magnified. Some look bright even when shown on a large scale, whereas others look dull and heavy on quite a small screen.

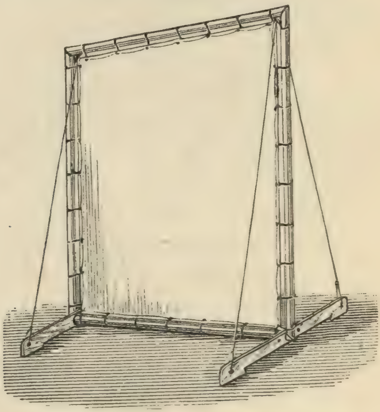

Fig. 28.—Simple Screen Stand.

In choosing slides, the preference should always be given to those which appear to be the most transparent when looked at through the light.

## THE SCREEN STAND.

*The Screen Stand* is a very useful accessory. Indeed,

Fig. 29.—Wooden Foot for Screen Stand.

it is almost indispensable if a large screen is to be put up in a room where it would be inconvenient to drive

nails into the walls. A good screen stand not only supports the screen, but keeps it stretched and steady. Fig. 28 shows a simple but very efficient stand which

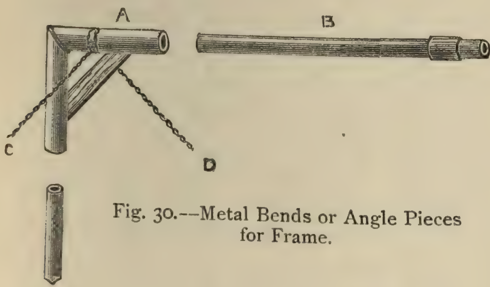


Fig. 30.—Metal Bends or Angle Pieces for Frame.

the amateur will find no difficulty in making. It can be used for screens of different sizes, and is as portable as a stand could be. It consists of two wooden feet, one of

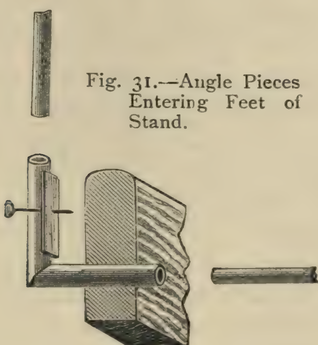

Fig. 31.—Angle Pieces Entering Feet of Stand.

which is shown in Fig. 29, each about 4 feet long; two metal bends, A, Fig. 30; two corner-pieces, Fig. 31, also of metal; and a number of ash poles, B, Fig. 30, about 1 inch in diameter. A tube is fitted to one end of each of

these poles, so that three or four of them may be joined together end to end as in a fishing-rod. We ought to have twenty poles 3 feet long, and four poles 4 feet long. This will enable us to use the stand with screens of 7, 9, 10, 12, 15, and 19 feet square. Supposing we want to put up a 12 feet screen, we use sixteen of the 3 feet poles, four at top, four at bottom, and four on either side. Of these sixteen poles, four must be without connecting tubes, as the metal bends which are fixed in the feet with thumbscrews and the two corner-pieces take the place of four connecting tubes. Begin by placing the two feet in the required position, and about 12 feet apart; then put four of the poles together to form a 12 feet rod for the bottom of the screen. Fasten one of the two angle pieces into the aperture in each foot by means of thumbscrews as in Fig. 31; and put the ends of the two outer poles of the rod you have just formed into the angle-pieces, by doing which you connect, as it were, the two feet, and form the lower end of the frame. Now put four more poles together to form the top of the frame, and put one of the top bends, A, Fig. 30, on to each end, B. Tie the screen on to this rod by means of tapes sewn on to the edge at intervals of nine inches or thereabouts, or by passing strings through eyelet-holes made about nine inches apart along the edges. The tapes or strings should, of course, be tied in bow-knots, so that they can be easily untied when the screen is to be taken down. Some exhibitors lace the screen on to the rods; but I find it simpler to have separate ties; and, when properly managed, the screen will be quite as well stretched one way as the other, which, after all, is the important point. Now put a pole into the lower end of each bend, and tie the screen to them. Join the

next two poles in the same way to the first, tying the screen to them as you proceed; then put the last two poles into the angle-pieces on the feet, and complete the frame by connecting these poles with the sides. Tie the screen to the last two poles, and, finally, to the bottom rod. It should now be found tightly stretched and free from creases; but to keep it upright, the two cords, C, D, Fig. 30, are tied to the upper bends, and the ends brought down and fastened to the ends of the feet, the two holes shown in the figure (see Fig. 28) being intended for these cords. The bends and angle-pieces can be made of either tin or stout sheet brass. As shown in the engravings, they are made of two tubes cut off straight at one end, and at an angle at the other. These two tubes are soldered together to form a triangle. The bends are strengthened by the addition of a cross-piece as shown in the figure. The angle-pieces have a projecting strip or tongue soldered to the upright tube; this strip, being pierced with two holes, is used to fasten it by means of thumbscrews to the foot, as explained above. The diameter of the tubes must be such that the rods will slip easily, but not too loosely, into them. If the stand is intended to be used only with small screens lighter poles might be used; but those of 1 inch in diameter are the most practical for screens of all sizes. For a 15-feet screen twenty 3-feet poles would be required; or, if 5-feet poles are used, twelve. In putting up the stand you must, of course, get some one to help you, and if the screen is a very large one, two men should hold the frame while a third ties on the screen. A stand of this sort could also be used as a frame from which to hang the paper screen, and, as it requires no support, it can be put up in any part of the room. A light deal box

should be made to keep the poles, feet, bends, and angle-pieces in. The size of the box must depend upon the length and number of the poles.

## The Lantern Stand.

A modification of the photographer's tripod stand forms an excellent lantern stand and is not expensive. The legs are made on the telescopic principle: they are 4 feet long, drawing out to about 7 feet. Brass screw clamps are used to fix them in position, and the lantern can be inclined at any angle by raising or depressing the front leg. One of these tripods made of oak, with the clamps, etc., complete, can be bought for about £2.

The revolving and canting table forms an adjustable stand; it is fastened on to a strong table or box, and the lantern can be turned in any direction or raised or lowered without having to move the table. A stand of this description costs from about a pound upwards, according to size. It looks very neat, being made of polished mahogany. Of course a stand is not really required, as a good steady table or a large packing case will answer all the purpose, and there are few houses where a suitable table cannot be obtained. When the lantern is exhibited in a drawing-room the table or box should be covered with a dark cloth.

## The Reading Lamp.

As all the lights must be put out or turned down very low when the exhibition is about to begin, the lecturer who requires to read his lecture must have a reading lamp. Some reading lamps are enclosed in a desk which stands on a table, while others are fixed

to a rod which can be screwed to the floor. The new "Lecturer's Reading Desk," the invention of Mr. A. A. Wood, answers its purpose admirably. The sides and top prevent the light from escaping into the room, and when not in use fold down for portability. The desk should be placed on a high table, so that the lecturer can see his notes without having to stoop. As the lecturer stands beside the screen, the back of the desk is, of course, turned towards the spectators, and it is provided with a lever arrangement by which the lecturer is able to display a red light when he wishes the operator to change the view.

## Paraffin Measure.

A flat tin bottle, forming a measure, and a funnel are useful for filling the reservoir. If the former is made $4\frac{1}{2}$ inches high by $2\frac{3}{4}$ inches by $1\frac{3}{8}$ inches, it will hold sufficient paraffin for an evening's entertainment, and will pack inside the chimney; the funnel may also be made of tin, and if it is made oblong and of the same dimensions as the top of the bottle, it will fit on it when not required.

## The Lantern Box.

As the lanterns should never be left lying about with the lenses exposed to dust and damp when not in use, *The Lantern Box* will be found a very useful accessory. It can easily be made by the amateur carpenter out of any well-seasoned $\frac{1}{2}$ inch boards. The dimensions of a box to hold two lanterns, or double box, as it might be called, are $19\frac{1}{2}$ inches by $15\frac{1}{2}$ inches by $5\frac{1}{2}$ inches (inside measurement). A shelf divides the box into two compartments, each just large enough to hold a lantern with its lamp, the chimney, the

dissolver, a paraffin measure, and some rag, etc. The box opens at the end, and the lanterns are generally slipped in back foremost. Turned on its side the box forms a stand for the lanterns, and the dissolving apparatus can be fixed to it with a couple of thumb-screws. It can also be used for putting the slides in during the entertainment. A simple handle that does not get in the way can be made by screwing a strip of stout leather to the top. For a single lantern, the box should be 15½ by 9½ by 5½ inches.

## Dissolving Views.

*Dissolving Views* must next engage our attention. This very pleasing effect was first shown by Mr. Childe in the early part of this century. It is produced by means of two lanterns. A sort of metal comb is moved in front of the lanterns in such a way as gradually to shut off the light from one, while that from the other is as gradually admitted to the screen. Before we can give a dissolving view entertainment, therefore, we must provide ourselves with a second lantern similar to the one before described. It must have a condenser of the same size, an objective of the same focus, and a lamp of equal illuminating power. The two lanterns are placed side by side, but must be turned *slightly* towards each other, so that the two discs on the screen may exactly coincide or overlap. A slide must be put into each lantern and focused, the light meanwhile being shut off from the other lantern. A separate slide-holder must, of course, be used for each lantern. The dissolver is made in a variety of shapes, and sometimes moves horizontally and sometimes vertically, but the principle on which it works is always the same.

Fig. 32 shows a dissolver well adapted to our apparatus. It might be cut out of stiff cardboard or a thin bit of wood, and blackened on both sides; but it is better to cut it out of tin, and japan it. You can cut it out of one piece; but it is more handy if made in three pieces (a centre-piece, A, Fig. 33, and two flaps, B). In either case it must be 11 inches in extreme length from the points of the combs or teeth, and $7\frac{1}{2}$ inches in height. The width of the arms or flaps is $3\frac{1}{2}$ inches, and the length of the teeth $1\frac{3}{8}$ inch. When it is made in three pieces, the two flaps are hinged on to the centre-piece, as shown in the figure,

Fig. 32.—Dissolver for Dissolving Views.

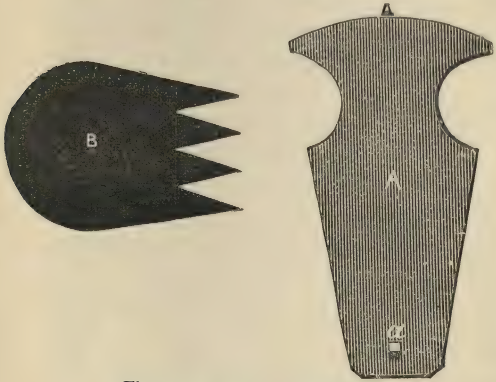

Fig. 33.—Parts of Dissolver.

the advantage of which arrangement is that a disc from both lanterns can at any time be projected on to the screen by merely putting the dissolver midway between the nozzles of the objectives and turning out

the flaps. The light from both lanterns can then pass freely to the screen.

The dissolver is fastened to a brass or wooden rod about a foot long, and, say, $\frac{1}{2}$ inch in diameter. One end of the rod is squared to fit into the hole, *a*, of the dissolver, which is kept in position by a metal washer and a thumbscrew, screwing into the end of the rod. A stand for the rod can be made of a piece of wood about 10 inches long and 2 inches wide, and $\frac{1}{2}$ inch thick. This piece of wood should have a couple of thumbscrews for fixing it to the box or table on which the lanterns are placed. Two brass screw-rings of suitable size, screwed into the stand near each end, will form simple but efficient holders for the rod. It should, of course, turn somewhat stiffly in them, so that the dissolver may remain in the position you wish. A couple of nails or plugs should be driven into the rod to catch against the stand when the dissolver is fully off either lantern; this prevents you turning the dissolver too far in either direction. The exact position of the plugs or stops must be found out by trial. A small wooden handle terminating in a screw is used for turning the dissolver; it screws into the under part of the rod, and hangs down in front of the lanterns, or rather between them.

The proper position for the dissolver is about 1 inch in front of the objectives when correctly focused. Supposing we now put a slide into the carrier in the right-hand lantern, then, as soon as we are ready to begin dissolving, we slowly move the handle to the right and continue to move it without jerking it, until we see that the points of the comb are off the lantern, or until the catch stops

us. We must then change the slide in the left hand lantern, and when it is to be shown, move the handle towards the left, as gradually as before, until the second catch stops us, and so on, alternately moving the handle towards the lantern we wish to bring "on the screen."

## CHAPTER IV.

*THE BI-UNIAL LANTERN—THE TRIPLE LANTERN—THE LIMELIGHT—THE RETORT—THE PURIFIER—THE GAS BAG—HOW TO MAKE THE OXYGEN—THE OXY-CALCIUM JET—PRESSURE BOARDS—THE LIME CYLINDERS—THE LIME BOX—THE CHIMNEY HOLDER—HOW TO USE THE OXY-CALCIUM JET.*

THE double, or, as it is more often called, bi-unial lantern is generally used for producing the dissolving view effect. One of these lanterns, made by Messrs. Watson and Sons, of High Holborn, is shown in Fig. 34. It is a first-class, strongly-made instrument; it has two sets of lenses and condensers and two sources of light, one over the other. The body of the lantern is divided by a metal partition so as to form two compartments. It is constructed of polished mahogany lined with metal, with two doors on each side. These doors have a small circular opening in the centre, fitted with a coloured glass to serve as a window. The front of the lantern, as well as the two slide-stages, the lens tubes, etc., are of polished brass; the condensers are of the standard size; the lenses are a good achromatic combination with rackwork adjustments. With lanterns of this description, which are only intended to be used with the limelight, the dissolving effect is almost always pro-

duced by means of a simple contrivance, to be described further on, called the dissolving-tap. A modification of the dissolving comb could of course be used; but as the dissolving-tap effects a considerable saving in the consumption of the two gases, it has practically

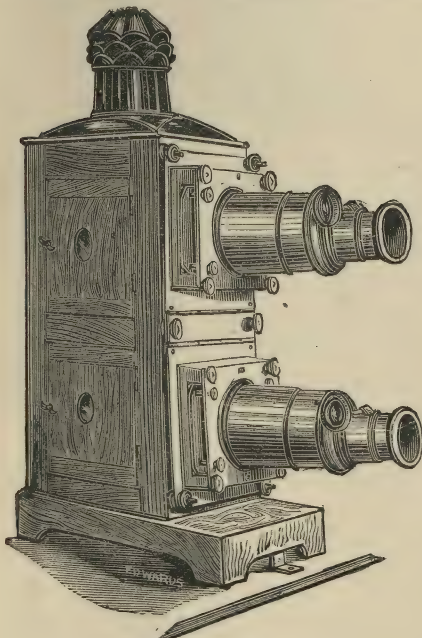

Fig. 34.—The Bi-Unial Lantern.

superseded the dissolver when working with the lime-light.

## THE TRIPLE LANTERN.

Fig. 35 shows one of the triple lanterns. This beautiful instrument consists really of a double lantern and a single lantern placed one over the other. The lantern

shown in the figure is made by Mr. J. H. Steward, and is the class of instrument used by most of our lecturers. The body is made of well-seasoned polished

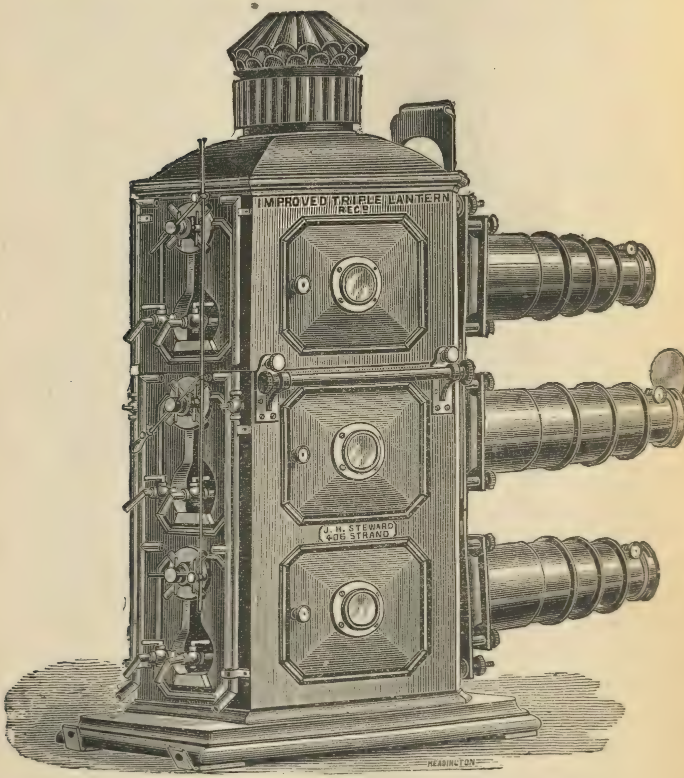


Fig. 35.—Triple Lantern.

mahogany, metal lined; it has six panelled rosewood doors, three on each side, with circular coloured glass discs let into the centre of each to form windows. The fronts are of polished brass; the plates forming the

supports of the slide-stages are made to adjust up and down, so that the discs thrown by the three lenses may be made to register exactly on the screen, and when they have been adjusted they can be fixed in position by means of clamping screws. The stage is open all round, and every kind of effect slide can be shown. The slides are held firmly in position by a spring-plate acted upon by spiral springs. The focusing tubes are telescopic, and consist of three brass sliding tubes, which can be drawn out from 4 inches to 11 inches, the advantage of which is that lenses of different foci may be used. By changing the lens-combinations different sized discs will be projected on the screen without altering the position of the lantern.

The top lantern can be removed, fitted on to a separate base-board, and used as a single lantern; the lower part of the instrument will then form a bi-unial lantern, an extra top and chimney being fitted on to it.

With the triple lantern certain effects can easily be shown which could not be produced with the double lantern. Again, when an effect requiring a double lantern is shown in the triple lantern, the next picture or effect can be placed in the third portion of the lantern and dissolved on to the screen while the effect is being worked.

The dissolving-tap used with the triple lantern will be described later on.

## The Limelight.

Although the lamp we are supposed to have used in our lantern will do well enough in small rooms, and is very handy and easy to manipulate, yet, if we wish

to show our slides on a large screen, we must have recourse to a much more powerful light. Such a light is

*The Limelight*, which, taking it all in all, is the best light for the lantern. It was introduced more than half a century ago, and was first called the Drummond light. It is produced by blowing a fine stream of oxygen through a flame of spirits of wine or hydrogen on to a disc or cylinder of lime. The part of the lime exposed to the action of the oxygen immediately becomes white hot, and so incandescent as to be almost painful to the unprotected eye.

When the light is produced with spirits of wine and oxygen it is called the oxy-calcium light, to distinguish it from the light produced by means of oxygen and hydrogen, which is called the oxy-hydrogen limelight. The former is less powerful than the latter, but as it is the more easily produced of the two, I will describe it first. The following apparatus will be required: a burner (or oxy-calcium jet, as it is generally called) to fit inside the lantern; two lengths of india-rubber tubing, one about 4 feet long and the other about 2 feet; a retort large enough to hold some two or three pounds of the chlorate of potash and manganese mixture from which the oxygen is obtained; a purifier for freeing the gas from impurities and cooling it; an air-tight bag or other receptacle in which to collect it; a pair of pressure boards for forcing it out of the bag when required; two or three weights (say one of a quarter of a cwt., and two of 14 lbs. each); and a lime cylinder.

### The Retort.

If the amateur lanternist has a laboratory, he will be sure to have a retort, which, of course, he can use

for making oxygen. If not, he will have to buy one, as a retort is not a thing that he can make himself. It must be well made, to stand the heat of the fire and the rough usage to which it is almost sure to be subjected in making the oxygen. The retorts sold by the opticians for the purpose are made of iron or copper, most frequently of the former metal, because of its greater strength and cheapness. They are made of different shapes and sizes. One form is shown in Fig. 36. It is made of sheet iron, and as the bottom is large in proportion to its height it is well adapted for use with a gas burner or stove. It has a brass screw top, into which is fitted a piece of iron piping about a foot long. An india-rubber tube connects this pipe with the purifier. In using it care must be taken not to heat it too quickly, or the oxygen will be generated faster than the connecting tubes can convey it away, and one of them will be blown off and some of the gas wasted. The so-called Safety Retort is a modification of the one just described. The safety arrangement consists of a second exit-tube fitted vertically into the screw-cap shown in Fig. 36. This tube is closed by a cork, and serves the purpose of a safety-valve, for when the oxygen is generated too fast the cork is blown out and the gas escapes freely. Copper retorts are of course much more expensive to buy; but they probably cost less in the long run, because when worn out they are still worth something as old copper, whereas the old iron retort is practically valueless.

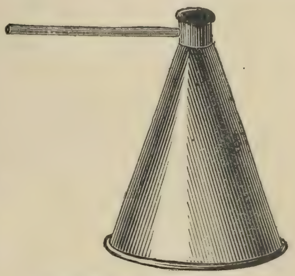

Fig. 36.—The Retort.

The price of iron retorts is from half a guinea upwards; the price of copper retorts is about eighteen shillings. The retort can be heated either on a Bunsen's burner or on a clear fire. The Bunsen's burner is preferable to the fire, as the heat can then be increased or diminished so as to regulate the flow of the gas.

## The Purifier.

The use of the purifier is to cool as well as purify the oxygen. A very good purifier can be made out of a wide-mouthed glass bottle or jar, as shown in Fig. 37. The two tubes, A and B, pass air-tight through a plug or cork, the tube A goes down to within about $\frac{3}{4}$ inch of the bottom of the bottle, the other tube (B), called the exit tube, is only 3 or 4 inches long. When required for use the bottle is about two-thirds filled with water. The purifier sold by the lantern makers is generally a zinc receptacle with two brass screw rings soldered into the top; two corresponding rings are soldered on to two brass tubes, one of which is long enough to extend to within $\frac{1}{2}$ inch or so of the bottom of the vessel when the tube is screwed into the ring, and the other is only 3 or 4 inches long. The former is of course the inlet and the latter the exit tube. A couple of washers are used to make the joints gas-tight. The advantage of having the tubes removable is that the vessel is easier filled and emptied, and if by any chance one of the tubes should get blocked it can be easily cleared. The tubes should be rather larger than the

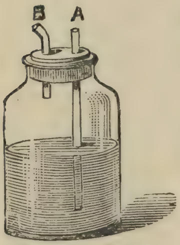

Fig. 37.—The Purifier.

india-rubber piping, so that the latter on being sprung over the ends may fit tightly to them.

## The Gas Bag.

*Gas bags* are made in the shape of a wedge, and, of course, vary in size according to the amount of gas that they are intended to hold. They are made thick and thin: the former may be used with any jet; but the latter should be used only with the oxy-calcium jet or with the safety jet, as the pressure required to be put upon the bag when working with either of these jets is not nearly so great as when the mixed gas jet is used. The thin bags are made of Jeanet india-rubber cloth, and are generally of a drab or putty colour; the thick bags are made of the stoutest twill india-rubber cloth, and are strong enough to stand a considerable pressure. They are, indeed, tested to stand a far greater pressure than you are ever likely to subject them to. A brass tap is fitted into the middle of the apex of all these bags, and it is by means of this tap that they are both filled and emptied. It is customary to speak of the bags by their cubical contents and not by their actual dimensions; but it is difficult to say exactly how much a bag of given dimensions will hold, because, in the first place, gas being compressible, it is hard to tell when the bag should be considered full; and, in the second place, as the sides and end of the bag swell out the more the bag is filled, it is not easy to determine its actual size. However, it is not necessary to know

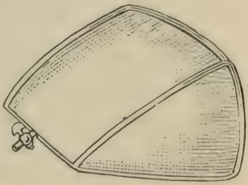

Fig. 38.—The Gas Bag.

the exact cubical contents of the bag: an approximate estimate will suffice.

| | | | | | | |
|---|---|---|---|---|---|---|
| A bag | 27 by 21 by 15 in. | will contain about | 4 | cubic | feet of | gas. |
| ,, | 30 by 24 by 18 in. | ,, ,, | 5 | ,, | ,, | ,, |
| ,, | 38 by 26 by 24 in. | ,, ,, | 8 | ,, | ,, | ,, |
| ,, | 42 by 30 by 24 in. | ,, ,, | 10 | ,, | ,, | ,, |

These are the usual sizes, and if the amateur intends to use different jets at different times, he had better get two of the larger thick bags; those of the capacity of 8 cubic feet will suffice for an evening's dissolving view entertainment. One of these bags will be required for storing oxygen and the other for hydrogen or coal gas. The bags, once having been used for oxygen and hydrogen, must henceforth be kept for those gases. Hydrogen should never be stored in an oxygen bag, or *vice versâ.* As the bags are alike it will be found advisable to paint a conspicuous O on the side of the oxygen bag, and an H on the hydrogen one, to distinguish them. The small bags alluded to above are intended to be used with a single lantern for a short entertainment; they are very handy for trying your jets and slides with, when arranging your apparatus for an evening's entertainment, as, of course, it would not do to waste the gas in your large bags for this preliminary "light up." One of the bags is shown in Fig. 38. As the bags get stiff in cold weather it is necessary to warm them before filling them We must now see

## How to Make the Oxygen.

First be sure that the retort is clean and dry, and that there are no bits of straw, wood, etc., in it; then mix thoroughly together on a sheet of brown paper three parts by weight of chlorate of potash in

crystals, and one part of black oxide of manganese in powder. Put the mixture into the retort (taking care that no foreign ignitible substance gets in with it), screw on the top, and stand the retort on a Bunsen's burner or on a clear fire; then connect it by means of the longer piece of india-rubber tubing with the A tube of the purifier (which should be from half to two-thirds filled with cold water), and put the other piece of tubing on to the B tube of the purifier. Roll up the bag as tightly as you can from the thick end, so as to expel the air—the tap, of course, being opened to let it escape. Then, while it is still rolled up, shut the tap, and spread it out on a box or table so that it may be on a higher level than the purifier. The object of having it above the purifier is to prevent the water being forced into it by the rush of gas.

The water is often driven into the connecting tube, particularly if the purifier is too small or too full; but if the bag is raised it will run back into the purifier instead of being carried on into the bag. As soon as the gas is being freely evolved, which will be known by the quick bubbling in the purifier as well as by the pungent smell of the vapour escaping from the tube, you must slip the end of the tube on the tap of the bag, taking care to open the tap at the same moment.

The bubbling will continue and the bag will swell as long as any gas is being given off. The amount of gas that can be obtained from a charge of the mixture depends upon the quality of the chlorate of potash. No gas is given off by the manganese: its only use is to prevent the potash from evolving its oxygen too quickly. It might be washed from the spent charge and used over and over again; but as it is very cheap, and as

washing and drying it is rather a messy job, it is scarcely worth while taking the trouble to do so.

In calculating the quantity of the mixture to put into the retort, you should allow one pound of chlorate of potash for every four cubic feet of gas. In theory, a pound of the best potash will yield five cubic feet of oxygen ; but in practice, you will not get much more than four feet. A certain amount of gas is always lost by leakage at the connections, and a further amount is wasted in driving the air out of the tubes and purifier in the first instance.

The proportion of 1 part manganese to 3 parts chlorate of potash need not be strictly adhered to; many lanternists, indeed, mix them in equal proportions, while others put 1 part of manganese to 4 parts of potash ; others again mix them by guess work, and it does not seem to make much difference in the amount of gas obtained. The only thing is, that if you do not put enough manganese, the gas may be evolved faster than the connecting tubes can convey it away, and the tube may be blown off the end of the retort ; on the other hand, if you put too much manganese, the gas will be given off very slowly, and a greater heat will probably be required towards the end of the process. Again, it does not matter whether you use either or both of the substances in powder, or whether you have the manganese pulverised and the potash in crystals ; in fact, you may use them any way you like : the great thing is to have them pure, and to make sure when mixing them that nothing gets in with them. I mention this again, because it is really very important.

When the bubbling in the purifier ceases, it is a sign either that the charge is spent, or that more heat is required to evolve the rest of the gas. If your bag

is full, you know, of course, that the charge is spent, and you must then disconnect your retort from the purifier and remove it from the fire. Shut off the tap of the gas bag and stand it up. Empty the purifier, and when cool enough, wash out the retort. As the oxygen will not keep long in bags, it is absolutely necessary that it should not be made more than a few hours before it is to be used.

## THE OXY-CALCIUM JET.

Fig. 39 shows the oxy-calcium jet. It consists of a reservoir, A, connected by the tube, B, with the wick-

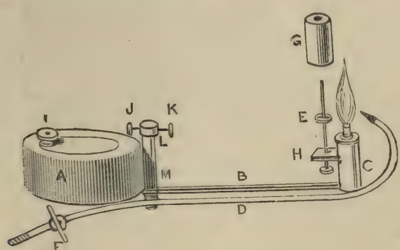


Fig. 39.—The Oxy-Calcium Jet.

holder, C. A second tube, D, parallel with the first conveys the oxygen to the burner. It terminates in a fine nozzle, which is turned towards the lime-pin, E. The tap, F, is for regulating the supply of oxygen, as it is important that the amount should be exactly proportioned to the size of the flame. The lime cylinder, G, shown immediately above the holder, fits on to the upright rod or pin, E, which screws into the horizontal bar, H. The reservoir, A, is a round flat tin box japanned on the outside, measuring $4\frac{3}{8}$ inches by 1 inch. One of the japanned tin boxes in which anglers keep their bait might easily be turned into a reservoir;

in fact, any box will do, and it may be square or oval, larger or smaller than the size indicated above, and of tin or brass. A reservoir of the dimensions given will hold enough spirits of wine to last out an ordinary lecture. It is filled by removing the little $\frac{1}{2}$ inch screw-cap, I, which has a pin-hole in it to let in the air when screwed on. The tube, B, is a piece of $\frac{1}{4}$ inch brass piping 6 inches long, soldered into a hole in front of the reservoir.

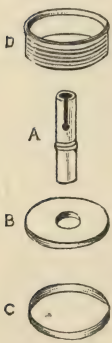

Fig. 40.
Parts of the Burner.

The wick-holder or cell, C, is made of a short piece of brass piping $1\frac{3}{4}$ inch long, and $\frac{7}{8}$ inch in diameter. This is the usual size, but it may be either larger or smaller, and if the amateur has a piece of piping of a different size by him, he can use it. A piece of brass is soldered into one end to form the bottom of the holder, and the end of the tube, B, is soldered into a hole in the side. The wick-carrier of an ordinary spirit-lamp should be fitted into the other end to form a burner. This is the simplest way of making the burner, but if the amateur should not happen to have a spirit-lamp of suitable size, from which the top can be removed, he must make a burner. It consists of the four pieces shown in Fig. 40: A is a little bit of $\frac{1}{4}$ inch brass tubing to hold the wick; it fits into the opening in B; C is a brass ring, which slides tightly into the cell, and forms a ledge or support for the piece B; D is a screw-ring which is meant to screw into the cell over the B piece to keep it in its place. The oxygen tube, D, Fig. 39, is another piece of $\frac{1}{4}$ inch piping $14\frac{1}{2}$ inches long. It passes under the reservoir and is soldered to it. One end terminates in the stop-

cock, F, the other is bent as shown in the figure, and terminates in a fine nozzle. Suitable nozzles can be bought at most of the lantern stores; they are made of brass, and are often tipped with platinum; they screw on to the end of the tube. The point of the nozzle should be on a line with the lime-pin, and $\frac{3}{8}$ inch from the end of the wick-holder.

The lime-holder consists of a metal rod $2\frac{1}{2}$ inches long, working in a collar either soldered direct to the upper part of the wick-holder, or sliding on a horizon-

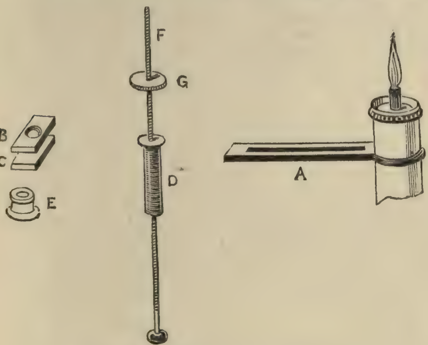


Fig. 41.—The Limc-Holder.

tal bar which is soldered to the wick-holder; the latter arrangement is shown in Fig. 41. A is the horizontal bar or support: it is of brass, and is soldered to the back of the wick-holder. A piece of stout brass wire bent into the form of a long U, the sides being parallel, would do well. It should project about $1\frac{1}{2}$ inch from the wick-holder. There are two little cross-pieces, B, C, to fit on to the support, one being placed above and the other below it. They are made to clench the bar (or wire) by means of the screw tube and thumbscrew, D, E, through which the limc-

pin, F, passes. This keeps the lime in its place. A screw is cut in the tube, D, and a corresponding screw on the lime-pin, so that the action of turning the lime round raises or lowers it; G is a small metal disc for the lime to rest on.

The support for the jet is shown in Fig. 42. It is a shallow tray made of tin and japanned. It slides in the grooves in the bottom of the lantern, and the jet is fixed to the upright rod, A. The tray is $5\frac{1}{2}$ inches long by $4\frac{1}{8}$ inches wide, with a tongue soldered on to the bottom at each side; the rod is 5 inches long. The rod is firmly soldered to the bottom of the tray at one end, and near it is fixed the brass ring, B, by which the tray is pulled out of the lantern. The jet is fixed to the rod by means of the little thumbscrews, J, K, Fig. 39, which screw into the collar, L, on the tube, M. This tube is somewhat larger than the rod, and slides on it. It is soldered to the reservoir and to the two tubes, B and D. When secured to the rod, the jet should be perfectly horizontal. Our jet is now ready for use, but before trying it, we must get a pair of pressure-boards and some lime cylinders.

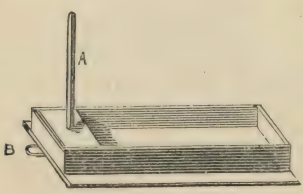

Fig. 42.—Tray for Jet.

### THE PRESSURE-BOARDS.

*The Pressure-Boards* are shown in Fig. 43. They are made of any light wood. You want two sets of boards, some 5 or 6 inches larger than your gas bag; these boards are hinged together at one end with a pair of stout iron hinges. The boards are then

opened, and the gas bag put between them, a semicircular hole, A, having previously been cut out of the upper board midway between the hinges, to let the tap through. A ledge and flap, generally hinged on so that they may lie down flat when not in use, are required to support the weights by which the pressure is given to the gas. They are placed near the upper end of the top boards as shown in the figure.

The dimensions of the boards will depend, of course, upon the size of the bag which is to be placed between them; it is better to make them too large than too small, as small bags may be used with large pressure-boards, though large bags should not be used with small boards; in fact, except that large boards take up a lot of room, and are heavy and unwieldy, it would not matter how large you made them. If you intend to use only small bags, pressure-boards measuring 32 inches by 26 inches will probably be found the most convenient; but, if you are going to give dissolving view entertainments, for which you will require large bags, you had better make full-sized pressure-boards, say 44 inches by 36 inches. Their construction is so simple that the amateur carpenter will find no difficulty in making them. The double pressure-boards, Fig. 44, are for use with two bags. They are more convenient than two separate pressure-boards would be, and, of course, take up less room. One set of weights, too, suffices, and the pressure on both bags must be equal all the time the lecture lasts—a matter of no little

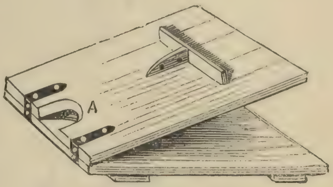

Fig. 43.—Pressure-Boards.

importance, as we shall see later on. The bags are so placed as to feel the full effect of the pressure of the weights (which is not the case with the ordinary pressure-boards), so that less weight would be required to produce the same effect. The arrangement consists of a set of pressure-boards, the end of the lower one of which is hinged to the inner edge of a stout frame, B. This frame lies on the floor, and the boards are raised above it by means of the wedge or lever, A. If the boards are large, two levers should be used. C is a sheet of canvas to prevent the bags from touching; D, a strap for keeping the bags in their place; E, the ledge for the support of the weights; and F the aperture for the taps.

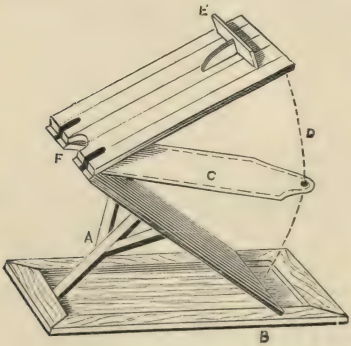

Fig. 44. –Double Pressure-Boards.

In an emergency you can make a set of pressure-boards out of the top of a packing case. The top must be somewhat larger than the bag you intend to use. You first screw two strong hinges on to one end of the top, then cut out a semi-circular opening midway between the hinges as in Fig. 43. This opening is, of course, for the tap, and should be some three or four inches across. A strip of wood must be nailed across the boards at a distance of about a foot from the other end to form a ledge for the support of the weights. Another piece of wood ought to be nailed on to the other end of the board just above the hinges to

strengthen the top. The hinges are then screwed down to the floor near where the lantern is to be placed. When you want to use your gas all you have to do is to raise the board and put your bag under it; but before doing so you must make sure that there are no nails or sharp splinters of wood sticking out under the board which could make a hole in the bag. If you should happen to make a hole in it you can stop it up temporarily with a piece of sticking-plaster, or with a piece of an old india-rubber coat fastened over the hole with india-rubber solution. This last, if properly applied and allowed to dry thoroughly before pressure is put upon the bag, should last some time.

## The Lime Cylinders.

*The Lime Cylinders* (usually called the limes) are of two kinds, hard and soft. The former are intended to be used with the mixed gas jet; the latter are used with the oxy-calcium jet, and sometimes, but not always, with the "blow-through" jet. They are cut out of lumps of unslaked lime, and should be about $1\frac{1}{2}$ inch long and 1 inch in diameter; they have a hole up the centre about $\frac{3}{16}$ inch in diameter. The best way of making them is first to bore a hole in a piece of lime, then to cut out the cylinder as evenly as you can with a knife, and finally to turn it in a lathe, or if you have no lathe smooth off the edges with a file. The hard limes are generally a little smaller than the soft ones; the size, however, is of no consequence; but it is advisable to turn a number when you are about it, and to turn them all the same size, as then when you have adjusted your lime-holder you will not require to alter it when putting on a new lime. As lime has such an

affinity for moisture, if the cylinders were left exposed to the air they would soon absorb moisture from it, swell out, and fall to pieces. So that to keep them it is necessary to pack them up in damp-proof boxes or bottles. The usual way of storing them is to put a dozen into a wide-mouthed bottle or round tin box, and then to shake pieces of the same lime round them, filling up all the interstices with powdered lime, taking care to dry the powder thoroughly before putting it round them. The bottle must be corked up, and, as an additional precaution, you may seal over the cork. The boxes are soldered up or bound round with tinfoil. Sometimes each lime is wrapped up in tinfoil before it is put into the box; but if you want to keep them for

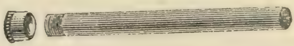

Fig. 45.—The Lime-Box.

a long time you should dip them in a preservative solution—the best is that made by dissolving common india-rubber in benzole. This solution must be kept in a stoppered bottle, and can be used again and again.

Chalk may be used as a substitute for lime if the latter cannot be obtained, and the amateur wants to "light up" in a hurry; but the chalk-light, if I may so call it, is far inferior to the limelight, and, moreover, the chalk cylinders waste so quickly that they would be very inconvenient to use except as a last resource.

## The Lime-Box.

The lime-box shown in Fig. 45 is handy for keeping a supply of limes in for immediate use. It is made of

brass and has a screw top. It can easily be made out of a piece of brass tubing large enough to hold six or nine limes placed end to end. A disc of sheet brass soldered into one end forms a bottom, and the top can be made either to screw or to slide on.

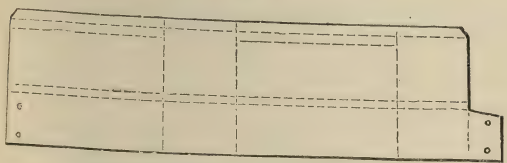

Fig. 46.—Piece for Chimney-Holder.

## The Chimney Holder.

One thing more remains to be done before we can try our jet in the lantern, and that is to make a stand or holder for the chimney. There is no necessity to make a chimney for use with the limelight, as the telescopic lamp-chimney I described in a former chapter will do. The holder can be cut out of a piece of sheet

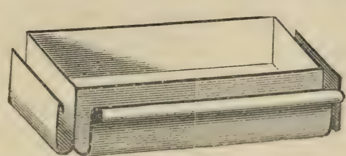

Fig. 47.—Chimney Holder.

iron or brass $10\frac{3}{4}$ inches by $2\frac{3}{4}$ inches. It is of the form shown in Fig. 46, and, when put together, fits in the aperture on top of the lantern. The chimney rests in deep grooves formed by turning up the ends and sides of the strip as shown in Fig. 47. Three-quarters of an inch is allowed for overlapping, and the holder is fastened with rivets.

## How to Use the Oxy-Calcium Jet.

The jet can now be tried. First fix it to the upright rod on the tray, then put some cotton-wick into the burner and pour some spirits of wine into the reservoir. As soon as the wick is soaked, light it, and put a lime on to the lime-pin to warm; then run the tray into the grooves in the lantern, and, if necessary, alter the position of the jet on the rod so as to get the lime about on a line with the centre of the condenser. Now put your oxygen bag between the pressure-boards and connect it with the jet-tap by means of one of the lengths of india-rubber tubing. The tubing that you used in making the gas can, of course, be used, only you must be sure to see that there is no water in it. Turn off the jet-tap, put a $\frac{1}{4}$ cwt. on the ledge of the pressure-boards, and then turn on the bag-tap. Once turned on, this latter tap should not be touched while the entertainment lasts. Any alteration in the flow of oxygen that may be necessary is always made by the jet-tap. When you are ready to light up, turn the jet-tap slowly until the flame of the burning spirit is almost "killed." You will then have a brilliant, steady, and pure white light not unlike the electric light, though not so powerful. There will probably be a dark shadow on some portion of the screen. This is owing to the light not being exactly in the centre of the condenser, and it is only necessary to move the jet one way or the other until you get rid of it.

Sometimes the pressure of the gas will be insufficient to enable it to overpower the flame, in which case an additional ten or twenty pounds must be put on the pressure-boards. In putting on weights lay them down very gently, otherwise the sudden rush of gas due to

the increase of pressure will be very likely to extinguish the light.

As the lime gets pitted by the action of the gas it is necessary every now and then to turn it partly round so as to expose a fresh surface to the flame: a good deal of light is lost if this is not done. When it is pitted all round it should be removed and a new one put in its place.

A lime cylinder shield has recently been introduced by Mr. Wood, who claims that by its use the lime is protected and the body of the lantern kept cooler. It consists of a thin metal cylinder which fits on to the lime-holder and encloses the lime.

The so-called automatic oxy-calcium lamp is another form of jet possessing some advantages over the ordinary one. It has a hollow circular wick, which is contained in an upright glass tube of suitable size, covered by a perforated metal cap or dome. This cap keeps the flame as small as possible as long as the oxygen is turned off.

## CHAPTER V.

*THE OXY-HYDROGEN LIMELIGHT — THE BLOW-THROUGH JET—THE MIXED GAS JET—HYDROGEN GAS—HOW TO USE THE OXY-HYDROGEN JETS—THE OXY-ETHER LIGHTS.*

IN the oxy-hydrogen limelight, hydrogen takes the place of spirits of wine. The oxygen is either blown through burning hydrogen, or the two gases are mixed in a small chamber at the end of the jet and impinge upon the lime; the former arrangement requires a "blow-through," or, as it is often called, "safety" jet; the latter requires a "mixed gas jet."

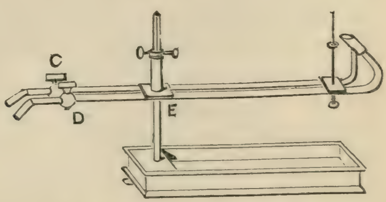

Fig. 48.—Blow-Through Jet.

### THE BLOW-THROUGH JET.

A blow-through jet is shown in Fig. 48, and a mixed gas jet in Fig. 49. As will be seen, there are in each

jet two tubes, one for the hydrogen and the other for the oxygen; these terminate at the outer end in the two taps, C and D, to which, of course, is attached the india-rubber tubing communicating with the bags. These tubes are soldered to the cross-piece, E, to which is fixed the upright tube with the thumbscrews for fastening the jet to the tray described in the last chapter. In the blow-through jet one of these tubes (usually the left-hand one) is turned up as shown in the figure, and terminates in a larger tube cut off at an angle to form a burner. This is for the hydrogen; the other tube is also turned up and directed towards the lime-pin. A fine

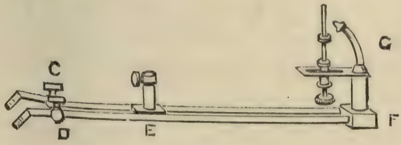


Fig. 49.—Mixed Gas Jet.

platinum-tipped nozzle is made to screw on to the end, and thus a fine jet of oxygen is blown through the burning hydrogen on to the lime, the proportion of each gas being regulated by the two taps, so as to obtain a pure white light without any visible flame.

## The Mixed Gas Jet.

In the mixed gas jet the two tubes open into the chamber, F. Here the gases get mixed and pass up the curved tube, G, at the end of which is a platinum-tipped nozzle similar to that used with the blow-through jet. The mixing chamber is more clearly shown in Fig. 50; F is a small brass casting, bored at one side with the two holes for the tubes, and having on top the cell or chamber into which the two holes open; H is

a brass tube made to screw into the upper part of the cell (or soldered on to it) to form a dome; G is a fine bent tube with a screw cap to enable it to be screwed on to the top of the dome piece; K is the nozzle.

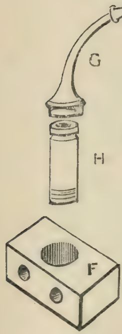

Fig. 50.
Front Part of
Mixed Gas Jet.

The lime-holder is a similar arrangement to the holder before described. It can either be fixed to the tubes as in Fig. 48, or to the burner as in Fig. 49. As the lime requires to be turned much more frequently when working with the mixed gas jet than with either of the others, a clockwork lime-holder was introduced some time ago for turning the lime at a uniform rate. It could be used with any jet, but is not really required with either the oxy-calcium or the blow-through jet. Another way of turning the lime without opening the lantern is to fit a cog-wheel arrangement to the lime-pin, as shown in Fig. 51; A is a cog-wheel fixed to the end of the lime-pin; B is a second cog-wheel fitted to the end of a lever which extends as far as the jet taps, where by means of a milled head it can be turned. A spiral spring is sometimes used instead of the cog-wheels, and answers better, as the lime can then be lowered or raised as well as turned. The spring is made of fine steel wire;

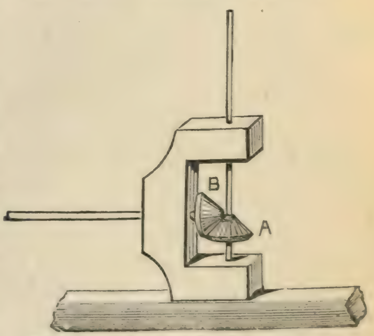

Fig. 51.—Cog Wheels for Turning Lime Cylinder.

one end is attached to the lime-pin, and the other to the lever.

Fig. 52 shows an interchangeable jet, that is a jet that can be used either as a blow-through jet or as a mixed gas jet. When arranged as shown in the figure it is a blow-through jet; but it is converted into a mixed gas jet by removing the burner and screwing the nozzle (shown separate) on in its place. This jet is fitted with the spiral spring lime turner.

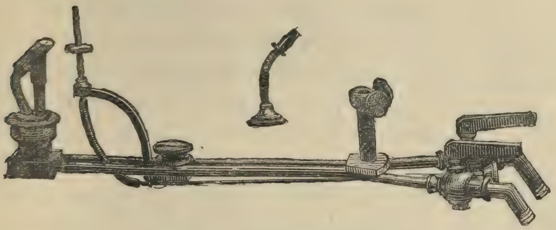

Fig. 52.—Interchangeable Jet.

## Hydrogen: How Produced.

Coal gas is generally used instead of pure hydrogen, because of the trouble of making the latter; but as there are still places where coal gas is not easily to be obtained, and as, moreover, pure hydrogen is preferable to carburetted hydrogen for the limelight, I will now describe how the former may be produced.

*Hydrogen gas*, being one of the constituents of water, is easily obtained by decomposing the latter. The apparatus required can easily be made, and the process is both simple and inexpensive.

We want a generator, a purifier, a couple of short lengths of india-rubber tubing, a few pounds of zinc scraps or granulated zinc, and some sulphuric acid (the common sulphuric acid of commerce will do, and is very cheap). A generator that any one can make is shown

in Fig. 53. It is a large, wide-mouthed glass bottle or earthenware jar, with a cork or bung fitting air-tight into the mouth. Into this cork are fitted the two tubes, A and B (glass or lead tubes should be used, not brass tubes, as the latter would be eaten away by the acid); one tube, A, forms an exit for the gas, the other, which reaches to within an inch or two of the bottom of the vessel, is used for pouring in the acid, and should have a small funnel at the upper end. The purifier is similar to the oxygen purifier already described. The india-rubber tubes are for forming the connections between the generator and the purifier, and between the purifier and the bag.

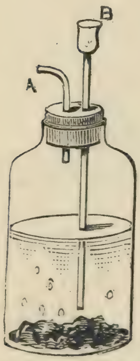

Fig. 53.—Hydrogen Generator.

When you are ready to make the gas, all you have to do is to put a layer, about an inch deep, of the zinc scraps on the bottom of the generator, fit on the cork, and then pour the sulphuric acid, diluted with about six times its volume of water, down the B tube until the generator is from half to three-parts full. Bubbles will immediately begin to rise from the zinc, but you must not connect your bag with the purifier just at first, because the air in the upper part of the generator as well as in the tubes and purifier must be driven out. It is better to lose a little gas than to get air in with it to your bag; and, of course, before the bag is connected with the purifier, it must be rolled up as before explained, to get rid of any air that may be in it. When the bubbling ceases, the addition of a little sulphuric acid to the liquid in the generator will generally start it again.

A larger apparatus in which the gas can be stored,

as in a gasometer, and which will work automatically, that is to say, will generate gas only as long as it is drawn off, can be constructed out of two barrels or large jars arranged as shown in Fig. 54. The zinc scraps are put on a shelf near the bottom of the lower barrel, which, of course, is shut at top, a large bung-hole being provided near the bottom, for putting in the scraps: this hole can be shut with a tight-fitting wooden or cork bung. The tube, A, forms the exit for the gas which is collected in the upper part of this lower barrel. The dilute acid is poured into the upper barrel in the first instance, and descends by the tube, B, into the generator (the lower barrel). The tap, C, being opened, the air will be expelled by the dilute acid which takes its place; the tap is closed as soon as all the air has been driven out, then the gas rising from the zinc, and unable to escape gradually, forces the liquid back into the upper vessel, and remains under pressure in the generator. When so much of the liquid has been forced out of the generator as to leave the zinc exposed, no more gas will be evolved; but as soon as some of the gas is withdrawn, the liquid flowing into the generator again covers the zinc and the action recommences, and continues until the generator is refilled with gas, or the charge exhausted.

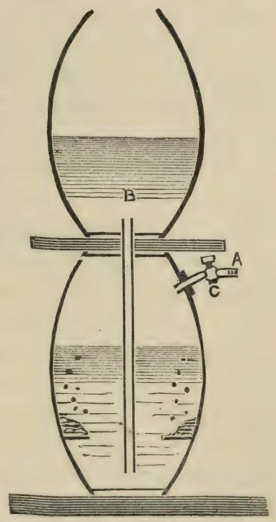

Fig. 54.—Barrel Hydrogen Generator.

If the barrels are of different sizes, the smaller might

be inverted and placed inside the larger one. The zinc scraps should be placed on a ledge near the open or lower end of the inner barrel, which must then be fixed in position in the outer barrel. This can easily be done by using four or five wooden plugs or wedges. A stopcock is fitted into the bottom, or rather (as the barrel is inverted) into the upper end of the inner barrel, and when the apparatus is to be used, all that you have to do is to pour the acidulated water into the outer barrel and open the stopcock. The fluid soon rises into the inner barrel, expels the air, and begins to act upon the zinc. Then as soon as the hydrogen is freely escaping, the stopcock is turned off, and the gas pressing upon the fluid forces it slowly out of the barrel, and gets stored up in the upper part of the same, where it remains under pressure, and ready for use at any moment. When the zinc scraps are above the level of the exciting fluid no more gas is generated, but as soon as some of the gas is drawn off, the fluid rises and covers the zinc, and the action recommences. Of course, this apparatus is a rough and cumbersome one, and is intended more as a makeshift than for constant use; still it will be found to work well, and is very easily put together. When the zinc scraps are used up, the plugs are knocked out, the inner barrel is removed, a fresh charge put in, and the barrel replaced. Cylindrical apparatus on the same principle can be made without much difficulty, but some metal, such as lead, which is not affected by the acid, must be used in its construction.

### How to Use the Oxy-Hydrogen Jets.

When coal gas is used in connection with a blow-through jet, it can be taken direct from the main if it is

laid on with sufficient pressure. All that is necessary is to remove the burner from the nearest chandelier, and to connect the gas tube with the hydrogen jet tap by means of one of the india-rubber tubes. You then put a lime on the holder, turn on the gas and light it. Put the jet into the lantern, and leave the gas burning to warm the lime and dry off any moisture that may have collected on the condenser while you get your oxygen bag ready. About one hundredweight should be put on the pressure-boards if you are using a large bag, but less if your bag is a small one. It is always better to have too much pressure than too little. If you are working with hydrogen from a bag, the same weight should be put on both pressure-boards, or you use the double pressure-boards, which equalise the pressure exactly. When you are ready to light up, you turn on the oxygen very gradually, and put your lime close to the end of the burner. You will have to manipulate the two taps so as to get exactly the right proportion of each gas. As in the oxy-calcium jet, the best light is obtained when the flame is almost "killed" by the oxygen. A little practice will enable you to judge how best to regulate the taps. It is often necessary to manipulate them at different times during the entertainment, so as to keep the light up to its full brilliancy.

In working with the mixed gas jet a very much greater pressure is necessary, and it is essential that the pressure on both bags should be equal. The hydrogen cannot, therefore, be used direct from the main. Iron 56 lbs. weights are the most convenient to use: of these, at least three should be put on each bag at starting. I generally work with four of these weights, and I have often had five on each set of

pressure-boards. Of course the greater the pressure the greater the consumption of gas, and the more particular must you be in seeing that your bags are sound and that your connections are well made. Indeed, it is often advisable to secure the india-rubber tubes to the taps by binding them round with twine or wire. There is sure to be a slight loss of gas by leakage, so that you must allow for it when filling your bags, and you should not put the weights on to the boards until the last moment. You ought never to put your foot upon the pressure-boards, or allow anyone to sit upon them or in any way interfere with them. This is important at all times, but is doubly so when using the mixed gas jet, with which an accident due to the rushing back of one gas into the bag containing the other would be very likely to occur if the pressure on one bag were thus suddenly increased.

### The Oxy-Ether Light.

This is another form of limelight which has been recently introduced. It is not intended to supersede the oxy-hydrogen light, but is meant to be used in connection with a mixed gas burner when common gas cannot be obtained, and it would be inconvenient to have to make hydrogen. The light is superior to the oxy-calcium, and the apparatus required is small and portable. In this light the oxygen, instead of being blown through a flame of spirits of wine or hydrogen, is charged with the vapour of ether, and is then conducted to one of the tubes of an ordinary mixed gas burner, where it is lighted and allowed to impinge upon a lime cylinder. A portion of ordinary or uncharged oxygen is blown through the flame thus produced by conducting it to

the other tube of the burner, and regulating the supply by means of the burner-tap. The light makes no noise in burning, and it is steady and very brilliant. The apparatus consists of a copper vessel divided longitudinally into two chambers, the lower chamber being subdivided into a series of small compartments, arranged in such a way as to make the oxygen pass through them all in turn. In doing so it becomes charged with the vapour of the ether contained in the vessel; it then passes into the upper chamber, whence it is conducted to the jet by an india-rubber connecting tube. As I mentioned before, only a portion of the gas requires to be charged with the ether vapour: it is, therefore, necessary to divide the supply into two parts as it is received from the bag or other receptacle, and this is done by means of a T tap, which is fitted into the inlet pipe of the vaporiser. The india-rubber tube coming from the bag is fitted on to one of the arms of the T, the other arm of the T is connected by means of another piece of india-rubber tubing with the oxygen tube of the jet. The oxygen on reaching the T tap divides into two portions, one going straight on to the jet, the other descending by the third arm of the T into the vessel.

*Great care* must be taken in working with this apparatus. To prevent a suck-back of the gas two safety pumice chambers must be interposed between the connecting tubes and the jet-taps. The safety pumice-chamber consists of a short piece of brass tubing of the same calibre as the india-rubber piping, filled with powdered pumice in wire gauze, to keep the pumice from falling out. Two of these safety chambers must always be used, one for each tube, and they should be placed as near the jet-taps

as possible. A piece of india-rubber piping a couple of inches long is sprung on to one end of the safety tube and bound round with wire; this little bit of tubing connects it to the jet-tap. One of the tubes from the ether chamber is connected to the other end. The connecting tubes *must be kept distinct;* that is to say, the tube used for the ignitible gas must not afterwards be used for the oxygen.

The oxy-ether limelight is suitable for many other purposes besides lantern demonstrations, and as the apparatus is portable and not liable to get out of order, it answers well for signalling at night. The cost of the sulphuric ether consumed during an evening's entertainment would not be more than a few pence, and as the lime cylinder is not so readily pitted, it lasts longer and gives a more uniform light. Once the supply of oxygen to the burner is regulated so as to obtain the maximum light, the jet-taps need not be touched for some time, whereas when the oxy-hydrogen light is used a frequent slight alteration of the taps is necessary to keep the light up to its full brilliancy. About one hundredweight should be put on the bag at starting. It is scarcely necessary to mention that the supply of ether should be kept in a well-stoppered bottle. Mr. Steward, who supplies the complete apparatus, has brought out a copper bottle with a screw-cap washer, which will be found very convenient for keeping it in.

# CHAPTER VI.

*DISSOLVING TAP—PLUG DISSOLVING TAP FOR TRIPLE LANTERN—GAS CYLINDERS—IMPROVED AUTOMATIC GAS REGULATOR—USEFUL HINTS—THE APHENGESCOPE—THE LANTERN MICROSCOPE—THE OXY-HYDROGEN POLARISCOPE—THE METAMORPHOSER—THE PHOTOMETER.*

THE dissolving tap is a tap or combination of taps for producing the dissolving effect when working with the blow-through or the mixed gas jets. The dissolving fan might, of course, be used, but the dissolving tap has this advantage over it, that it effects a great saving in gas. By moving a lever the gases are gradually turned off the jet in the first lantern, and as gradually turned on to the jet in the second lantern. Various forms of this tap have been devised, but the principle is the same in all.

Fig. 55 shows how the amateur may construct a dissolver for his own use. It will not be as neat an arrangement as the dissolving taps sold in the shops, but it will answer his purpose. Two Y pieces, a connecting tube of the same length as the distance between the arms of one of the Y pieces, five taps, four metal rods to form the levers, four screws, and a sliding bar and handle will be required. The two Y pieces are fixed side by side to a metal plate or

stand, A, which can be fastened by thumbscrews to the lantern-box. Four of the taps are soldered to the ends of the Y pieces, and to the handles of these taps are fixed the four levers; the other ends of the levers are made to work on pivots formed by the four screws on the sliding-bar. The taps and levers are so arranged that when the sliding-bar is pushed to the right, the left-hand taps on both arms will be open, and the right-hand taps shut; and when

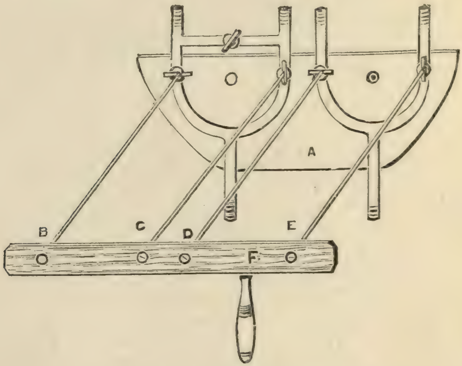


Fig. 55.—Amateur's Dissolving Tap.

the bar is pushed the other way, the left-hand taps will be shut, and the right-hand ones full open. The fifth tap is soldered into the connecting-tube, which is then soldered into the two arms of the left-hand Y piece above the taps, so as to allow the hydrogen to pass to the off jet after the gases have been turned on to the other jet. The use of the tap is for regulating the supply of gas to the off jet so that only just sufficient to keep alight may be allowed to pass over.

A dissolving tap of much simpler construction is

used in connection with the oxy-calcium jets, as it is only necessary in using them to turn the oxygen on and off each jet alternately. A single Y piece with a tap at the end of each arm connected by levers to a sliding-bar or handle will answer the purpose, but, of course, the other dissolving tap may also be used.

Fig. 56 shows another form of dissolving tap. It is, in reality, a six-way tap. The hydrogen and oxygen bags are connected with the tubes or nozzles, H and O, respectively. The hydrogen tap of one jet is connected with the tube A, and that of the

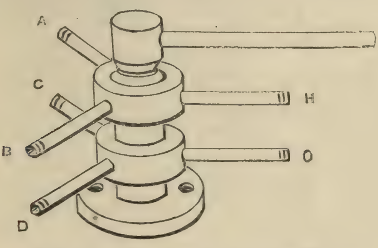


Fig. 56.—Another Dissolving Tap.

other jet with the tube B; the oxygen jet-taps are connected with the tubes C and D, the connections being made by means of short lengths of india-rubber tubing. The tap is fixed to the back of the lantern box or stand with thumbscrews. As soon as the connections are made the oxygen jet-taps are turned off and the hydrogen ones turned on; the handle of the dissolver is put mid-way between the tubes, which allows the gas to pass equally to both jets, and the burners are lighted; then the oxygen is turned on and the light regulated first in one lantern and then in the other. Now if we turn the handle to the left we shall shut off the gases from the left-

hand lantern, and turn them full on to the other one; then, if we turn the handle in the opposite direction, we shall turn them off the right-hand lantern, and full on to the left-hand one. The dissolving may be made as gradual as possible by moving the handle sufficiently slowly. It is evident that it would not do to shut off both gases entirely from the off lantern, as the flame would be extinguished, and we should be under the necessity of re-lighting the off jet each time we wished to dissolve. In the dissolving tap, accordingly, provision is made for the passage of sufficient hydrogen to the off jet to maintain a small flame.

### Plug Dissolving Tap for Triple Lantern.

The plug dissolver shown in Fig. 57 is an ingenious arrangement for distributing the two gases among the three jets of a triple lantern. There are, of course, two inlet and six outlet pipes. The former are connected with the oxygen and hydrogen supply tubes respectively, and the latter with the jet taps; then, by merely moving the lever, any one of the lights, any two of them, or all three, can be turned on.

### Gas Cylinders.

*Gas Cylinders* are now often used instead of the bags and pressure-boards. They are made of iron, and are filled by means of special apparatus. The advantages of using them are that they take up very little space, that when charged the gas can be kept in them for any length of time, and that they are ready for use at a moment's notice. The chief objection to them is that you must always send them up to London or to one of the large towns to be filled, and when the carriage of

them to and fro is added to the price of gas, it will be found, as a rule, that it is more expensive to use them than the gas bags and boards. However, they are very convenient, and will last long with ordinary care.

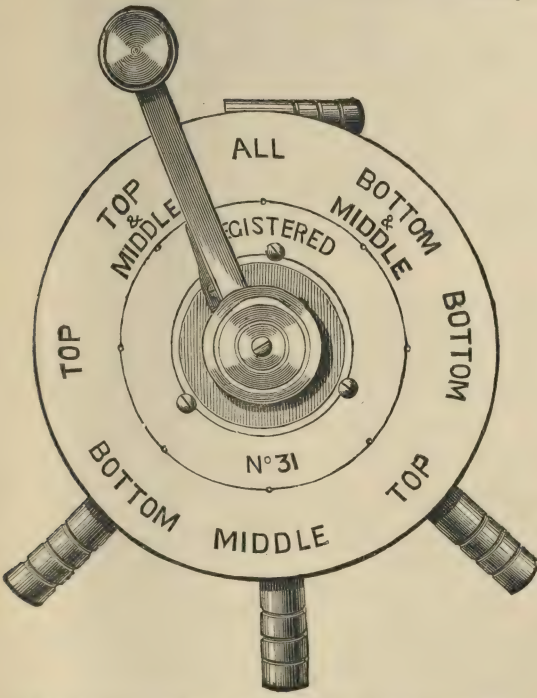


Fig. 57.—Single Plug Dissolver for Triple Lanterns.

Fig. 58 shows one: the nozzle, A, screws on to the top, B; a washer, or washers, being used to form a gas-tight joint. The exit is closed by a valve which is opened by means of the lever key, C.

When the cylinder is fully charged the pressure of the gas is so great that the valve must only be opened

a very little way. If opened too much or with a jerk the gas will be very likely to blow off the connecting-tube or burst it. In either case the loss of gas would be considerable. The moment you have put out your

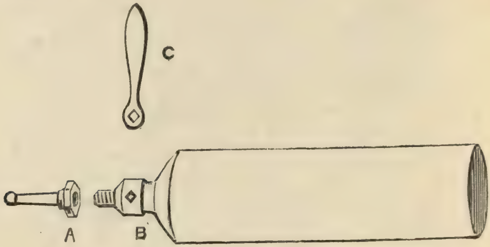

Fig. 58.—Gas Cylinder.

lights you must close the valve; it is not sufficient to turn off the jet-taps, because the gas will continue to force its way out of the cylinder as long as the valve is open. The cylinders are usually made in three sizes; the smallest holds between seven and eight cubic feet of gas, and the largest about double that amount. The largest are the most convenient, because they only require to be refilled half as often as the smallest. As it is very necessary to be able to ascertain from time to time how much gas the cylinder contains, the pressure-gauge, Fig. 59, has been introduced; it is made on the same principle as the steam pressure-gauge; the figures on the dial give the pressure in atmospheres. When the cylinder is "full" the indicator should point to thirty, that is to say, the gas is not compressed in the cylinder to a pressure exceeding thirty atmospheres.

Fig. 59.—Pressure Gauge.

A pressure of thirty atmospheres in a large cylinder is equivalent to about fifteen cubic feet of gas. The number of cubic feet is found by dividing the indicated pressure by two in the case of a large cylinder, or by four in the case of a small one: thus, if the indicator points to ten, we know that we have only five cubic feet of gas in the cylinder, because $10 \div 2 = 5$. If the cylinder was a small one, the same pressure would show that we had only $2\frac{1}{2}$ cubic feet of gas ($10 \div 4 = 2\frac{1}{2}$). This would be the actual amount of gas in the cylinder, but it is not all available for use, because a certain quantity will always remain in the cylinder, the pressure being insufficient to force it out.

Steel cylinders have been recently introduced, and bid fair to supersede the iron ones. They are smaller and very much stronger. They are made in two sizes; the larger, measuring about 33 inches in height by $3\frac{3}{4}$ inches in diameter, will hold 25 cubic feet of gas at a pressure of 110 atmospheres. Mr. J. H. Steward, who supplies these bottles, arranges for the filling of them when required. The new

### Improved Automatic Gas Regulator

is a very useful accessory for regulating the flow of gas from the bottle. It screws on to the top of the gas bottle, and can be set to deliver the gas to the jet at any desired pressure. The gas is under perfect control, and there is no fear of a sudden rush of the same when the bottle valve is first opened. Another advantage in using it is that the gas does not hiss, as it is apt to do when used direct from the bottle. It is made of brass, and is not expensive.

## Useful Hints.

If you have a case for your lanterns, always keep them in it, as it protects your lenses and condensers from the dust; never leave the lanterns in a damp place. Before you begin your exhibition warm your condensers, either at the fire or by lighting your lamp or burner. If there is any dust on the lenses blow it off or brush it off with a dry camel's hair brush before you wipe them. A soft silk handkerchief free from dust is the best thing to wipe them with. If you take the lenses out of their holders, be sure you notice how they are turned, so that you may be able to put them back the same way.

If you are using one of the old phantasmagoria lanterns with the Argand Solar lamp, burn camphorated sperm oil in it if possible. The next best oil is camphorated colza. In cold weather it would be advisable to warm the oil before putting it into the lamp. Do not fill the reservoir quite full. When the entertainment is over, if you are not likely to use your lantern again for some time, you had better empty out the lamp and remove the wick. The lamp should be filled and the wick turned down at least a quarter of an hour before you want to light up. This gives time for the wick to become saturated with oil. It can then be turned up a little and cut straight across the edge with sharp scissors.

In working with one of the new mineral oil lamps, carefully wipe off any oil that may have got spilt on the lamp when filling the reservoir. Do not fill the reservoir up to the top. Light the lamp with the wicks turned down, then draw out the chimney to its full length, put it on, and slide the lamp into the grooves

in the lantern. Wait for a few minutes after lighting the lamp before turning it up. If you turn it up too quickly you run the risk of breaking the front glass as well as the condenser. Turn up the wicks gradually and in turn until the best light is obtained.

When using the oxy-calcium burner first put the wick into the holder and let it project about a quarter of an inch above it, then fill the reservoir with methylated spirits and fix the burner on to the rod on the tray. Put a lime-cylinder on to the holder, slide the tray into the lantern and light the burner. Put the chimney-holder on to the lantern and put on the chimney. Then arrange the gas-bag between the pressure-boards, put a $\frac{1}{4}$ cwt. on to the ledge, and connect it with the burner. Turn the jet-tap off and the bag-tap full on, and then when you are ready to light up turn the jet-tap on gradually. If the pressure of gas is not sufficient to nearly "kill" the flame of the burning spirit, put another weight on to the boards. You should always work with the jet-tap turned slightly off, so that you may be able to turn on more gas when necessary. The best light is obtained when the supply of oxygen is exactly proportioned to the size of the flame. When the lime becomes pitted it must be turned partly round, so as to expose a fresh surface to the action of the gas.

In working with the oxy-hydrogen light, always make sure that the pressure is the same on both bags. If you have a mixed gas jet, you had better use two of the safety pumice interceptors previously described. When using them put them as near the jet as possible, and always use one for each tube.

The best place for the bags is in front of the lanterns—not behind. You must, in putting on the

weights, make sure that they will not fall off, and, if possible, always use flat weights in preference to round ones. Remember that the oxygen is the last to be turned on and the first to be turned off. Generally more hydrogen is consumed than oxygen, but this is not always the case. Sometimes when using the gases under heavy pressure a hissing noise will be heard; it can generally be stopped by pinching the oxygen connecting-tube to check the flow of gas for a moment; if this does not succeed, turn off the oxygen (at the jet-tap), and then gradually turn it on again; if the noise still goes on, turn off both gases, and then re-light them. Before using any jet you should make sure that the tubes and the nozzle are clear, and remove any dust that may have got into the connecting-tubes by blowing through them. If the connecting-tubes are too short to reach from the bag to the jet, two or more lengths may be joined by pieces of $\frac{3}{8}$ inch brass piping about three inches long. The ends of the pieces to be connected are sprung on to one of these tubes and secured with twine. In working with the mixed gas jet, some little care is required in regulating the exact proportion of the two gases, and it will often be found that a very slight turn of one or other of the taps will change a bad light into a good one. The proper position of the jet in the lantern must be found out by trial. Lastly, remember that the greater the pressure, supposing it to be the same on both bags, the less chance is there of an accident occurring when using the mixed gas jet.

In making the oxygen, take care that nothing gets into the retort with the chlorate of potash charge. Do not put the retort on too hot a fire; and if the gas seems to be generating too fast, which is shown by the violent bubbling in the purifier, at once remove

the retort from the fire; or, if you are using a Bunsen's burner, turn down the gas. Some exhibitors recommend binding the connections round with wire or string, but I do not consider it a good plan, as, if the pressure of the gas then becomes too great, the tubes, instead of being blown off, would be burst. The connecting-tubes, however, should always fit tightly on to the nozzles of the other tubes. As soon as your bag is full turn off the tap, and disconnect it from the purifier. Also be sure to disconnect the retort from the purifier.

Make the hydrogen gas, if possible, in the day time. Keep the hydrogen bag for hydrogen, and the oxygen bag for oxygen. Carefully expel all the air from both bags before filling them. Press out the gas that remains in them after the entertainment is over. Do not use the thin bags with the mixed gas jet. Make sure that there is nothing near the pressure-boards that would be at all likely to catch them in shutting down. The bags used in connection with the mixed gas jet should be alike in size.

Before commencing your exhibition, have everything you are likely to require ready to your hand, so that you may have no difficulty in finding it when the lights in the room are turned down. Always have a supply of extra limes by you. They should be kept in the lime-holder until the last moment. A pair of lime-tongs is very useful for removing a broken lime from the lime-holder. A supply of tapers is useful, and be sure you do not forget to have a box of matches handy.

The lanterns should be tipped as little as possible, as tipping them not only distorts the pictures, but makes it impossible to focus them properly. It is better to raise them by putting a small table on top

of a large one, or to erect a sort of platform for them. The lenses should be as nearly as possible on a line with the centre of the screen.

The slides should be warmed to expel moisture from between the glasses, and cleaned before they are shown. When working with two lanterns, I always arrange them in two sets, each alternate slide being put together. By this means it is almost impossible to show them in the wrong order, as every other slide must be put into the same lantern; and as the lanterns are lighted up alternately, the pictures will follow one another in the right series. Of course, one set should be placed in front of or beside one lantern, and the other set beside the other lantern. I doubt if it is necessary to repeat that the slides must be put upside down in the carrier.

## The Aphengescope.

The opaque lantern, or, as it is generally called, the Aphengescope, was introduced some twenty years ago for showing opaque objects, such as the works of a watch, photographic prints, leaves, flowers, coins, etc., on a screen. It consists of a metal or mahogany body, in which the opaque object to be shown on the screen is placed. This is put in front of the lantern, the slide-stage, lens-tubes, etc., being removed. The object must be strongly illumined, and the lantern turned with its back towards the screen, or nearly so. An image of the object is then thrown by means of a combination of lenses on to the screen. As there is a considerable loss of light in showing objects in this way, it is practically useless except with the limelight. The Double Aphengescope is a modification of the opaque lantern. It is intended to be used with two lanterns,

the light from both being concentrated on the one object. By this means more satisfactory results are obtained.

## The Lantern Microscope.

The magic lantern is well adapted for showing microscopic objects to a number of spectators at once. The lantern microscope is intended to be fitted on the front of an ordinary lantern, and will show the usual microscopic slides in the same way as photographic transparencies or painted slides are shown in the lantern. The lantern microscope may be briefly described as a pair of short focus lenses fitted into a lens-tube and placed at a greater distance from the condenser than the ordinary objective. When objects mounted in Canada Balsam are shown they should not be left too long in the microscope, as the heat from the lantern would probably injure them. Of course only transparent objects, such as the wings of insects, etc., etc., should be shown in this way. Opaque objects do not look well.

Lantern microscopes, to suit any lantern of the ordinary size, can be purchased at a moderate price of most opticians. Messrs. Watson and Sons have introduced a lantern microscope which, being combined with a right-angle prism, throws a picture of the object to be examined on to a sheet of paper spread on the floor immediately below it. By this means the object can be studied by a number of persons sitting round the instrument, and, if necessary, a drawing of it can easily be made.

## The Oxy-Hydrogen Polariscope.

The beautiful effects of polarised light can now be shown in the lantern. The polariscope is made to fit

on in front of any of the larger lanterns in place of the lens-tubes. As it is scarcely likely the reader will attempt to make a polariscope for himself, a detailed description of it is not given.

### The Metamorphoser.

This is a new magic lantern to burn mineral oil, fitted with a double condenser of the standard size. The objective is a combination of different sized lenses, the front ones being $\frac{1}{4}$ inch plate portrait lenses, and the back ones larger lenses, so as to throw as much light as possible on the screen. The lamp is a four-wick one, the wicks being two inches wide, and arranged like a W, thus forming a double wedge. The peculiarity of the lantern lies in the front arrangement. The slide stage, being movable, can be raised or lowered by means of a lever, the advantage of which is, that all kinds of slides, ordinary slides, rackwork, lever, panoramic slides, etc., can be shown one after another without any delay. And further, when using only one lantern, the white disc is not seen in changing the pictures, as they are introduced alternately into the upper and lower aperture in the slide-stage, and raised or lowered into position as the case may be.

### The Photometer.

It is often very useful to be able to estimate the power of your light. This can be easily done.

*A Simple Photometer.*—This is on the principle of the Rumford photometer, and consists of a paper screen fixed upright at one end of a table. White paper stretched on to a child's small hoop will do very well. A little way in front of the screen you must

fix an upright rod; then you get one of the standard candles and place it before the rod and in a line with it, so that a shadow may be thrown upon the screen; then put the light you wish to test beside the candle, so as to throw a second shadow on to the screen on a line with and close to the first. If this second light is more intense than that of the candle it will throw a stronger shadow, and you must move it back from the screen until the two shadows are equal. You then measure the distance of the candle from the screen and square it, and also the distance of the other light from the screen, and square it too, then divide the greater number thus obtained by the lesser, and the quotient is the candle power of the light. The standard candle is a sperm candle, burning at the rate of 120 grains an hour.

## CHAPTER VII.

*THE STANDARD SLIDE—THE PATENT ECLIPSE CARRIER — PAINTED SLIDES — PHOTOGRAPHIC TRANSPARENCIES—MOUNTING THE SLIDES—SILHOUETTE SLIDES—THE SINGLE SLIPPING SLIDE—THE DOUBLE SLIPPING SLIDE — THE SINGLE LEVER SLIDE—THE DOUBLE LEVER SLIDE—CONUNDRUM SLIDES—SIMPLE ASTRONOMICAL SLIDES —STATUARY SLIDES—THE SLIDE-TINTER—THE PANORAMIC EFFECT—RACKWORK SLIDES—THE CHROMATROPE.*

WE must now turn our attention to the slides, after which we will see how some of the best effects are produced.

*The Standard Slide* is, as I said before, $3\frac{1}{4}$ inches square, which on the whole seems to be a very practical size. Many slide producers have, unfortunately, adopted other sizes, so that at the present time there are slides of three or four different sizes in the market. Thus the slides which are taken on what the photographer calls $\frac{1}{4}$-plate glasses are $4\frac{1}{4}$ inches by $3\frac{1}{4}$ inches, and the French slides are about $3\frac{7}{8}$ inches by $3\frac{1}{4}$ inches, while the stereoscopic transparency when cut in half to form a slide is about $3\frac{3}{8}$ inches by $3\frac{1}{4}$ inches. These last, when not too dense, make very good slides. Those transparencies which look thin, or, in other words, seem to lack density in the stereoscope,

make, as a rule, the best lantern transparencies. As it is only the length of the slides that varies (the width being always the same), the carrier I have already described can be used with any and all of them. The only difficulty is in centring them; that is to say, pushing them into exactly the right position in the frame. With the $3\frac{1}{4}$-inch slides, the first is always brought into the exact position by pushing the second slide after it in the holder, until its outer edge is on a line with the end of the carrier; but it is evident that it would not do to push a longer slide in in the same way, as the first slide would then be pushed too far. What we want then is something to show us exactly how far to push them in when they are not of the standard size. The simplest plan is to screw a strip of wood to the top of the carrier, so as to project $1\frac{1}{2}$ inch beyond the end. This will do for the long slides, which are to be pushed in as far as the end of the wood. If you intend to show French slides, you must cut a notch in the wood $\frac{9}{16}$ inch from the end of the wooden strip, and push them in as far as the notch. For the half stereoscopes, you must cut a second notch in the wood, or gum a little wedge on to it $\frac{3}{16}$ inch from the end of the carrier. You will thus be able to exhibit slides of different sizes without changing or shifting your carrier. All you have to do, is to remember that the standard slides are to be pushed in flush with the end of the carrier, the half stereos as far as the first (or inner) notch, the French slides to the second (or outer) notch, and the long slides as far as the end of the wood only.

Chadwick's Registering Carrier is a good one. With it slides of all sizes can be accurately centred. It is simple in construction, and easy to use. In the Improved Facile Carrier, sold by Mr. Pumphrey, of

Birmingham, the slides are moved into position by means of a non-elastic band and held there by a clip. The slides are moved forward by turning a handle. This carrier also centres the slides.

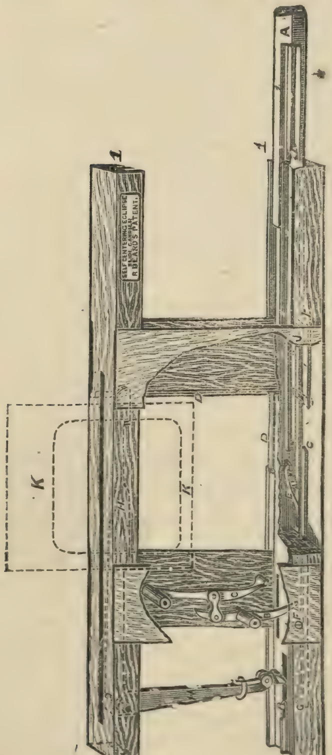


Fig. 60.—The Eclipse Carrier.

### The Patent Eclipse Carrier.

This very ingenious carrier, which was designed by Mr. Beard, and is sold by Mr. J. H. Steward, is probably the best in the market. It consists of a wooden frame, as shown in Fig. 60, with a metal runner, A, sliding in grooves in the lower part. The slide to be shown is placed in the outer of the two grooves in the runner, and the runner is pushed home. The picture will be exactly centred whether it be a short slide or a long one. The runner is then to be pulled back, and the action of doing this pushes the slide into the second groove, where it is held perfectly square and upright with the frame. It must be focused when in this position, and then every picture shown will be in the same focus. When the next slide is to

be introduced, it is put in the same groove in the runner and the runner pushed into the frame. The slide passes in front of the first one, and when centred by the levers, G and H, the runner is drawn back; this pulls out the first slide and pushes the second one into its place. K shows the mask with a cushion-shaped opening for reducing all the pictures exhibited to one uniform size. Square, round, or oval masks might be used. One great advantage in this carrier is that all the slides are introduced and withdrawn by the one action, as it were, and on the same side of the lantern.

## Painted Slides.

*Painted Slides* are much more difficult to prepare than many people suppose. The painting of slides is, in fact, quite an art in itself, and a good deal of practice is required to become proficient in it. When it is considered that a highly-finished picture has to be painted on a glass little more than 3 inches square, and that all the details have to be put in so delicately and neatly that the picture will bear magnifying to ten or twelve feet, the difficulty of the task becomes at once apparent. Outlines on glass can be used by those who wish to paint a series of slides but do not care to draw the pictures.

## Photographic Transparencies.

In choosing photographic transparencies for the magic lantern, the exhibitor should remember that dull heavy views look dull and gloomy on the screen, and, in fact, can only be shown with the limelight. Many transparencies which would look well if left plain are quite spoilt by being over-coloured. To my thinking, a really good photograph is never improved by being

coloured, and though, of course, coloured pictures are by many preferred to plain ones, there is no reason why our best transparencies should not be shown as they are. Variety is always pleasing, and a plain photograph comes in very effectively after a number of coloured ones. With plain photographic transparencies, too, the slide-tinter can be used, and thus the pleasing effect of different tints can be shown. The plan so frequently adopted of colouring every slide in the same way and with the same depth of colour—in other words, colouring them by the dozen without any regard to artistic effect—is most strongly to be condemned. They would look far better not coloured at all than coloured in this way.

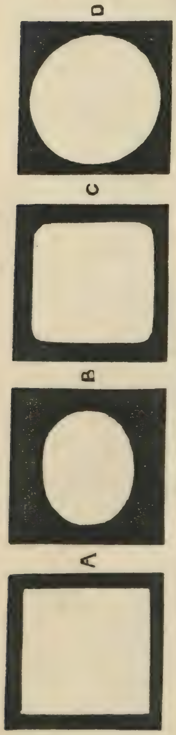

Fig. 61.—Mounts for Slides.

### Mounting the Slides.

Before passing on to describe the different "effects," I must say a few words on

*Mounting the Slides.*—Every slide, whether hand-painted or photographic, should be mounted with a plain glass over the face to protect it. A paper mount, square, oval, cushioned-shaped, or round, A, B, C, D, Fig. 61, is interposed between the slide and the glass, and forms a sort of frame for the picture. The edges of the glasses are then bound over with strips of gummed paper about ½ inch wide. Any paper will do; but that generally used is black or purplish brown.

The mounts ought to be black on one side and white on the other, so that if they are always put the same way between the glasses, you can tell at a glance which is the right or film side of the picture. If plain black mounts are used (and they are generally stamped out of sheets of black paper) you will find it a good plan to mark them on one side with white paint, or else to write the name of the picture on a strip of white paper and gum it on to one side of the mount. Before finishing off the slide, you should make sure that both it and the plain glass are clean and dry; you must also be careful that no dust or grit gets in between them. The plain glasses should, as a matter of course, be entirely free from bubbles and scratches.

Fig. 62.—Wooden Frame for Slide.

The slides are sometimes put into separate wooden frames. There is less chance of their being broken when thus mounted; but it makes them so much bulkier and heavier that the plan is not now often adopted. Fig. 62 shows one of the frames; it is made of four pieces of well-seasoned mahogany. Each piece is grooved so that when put together the slide is held all round by the grooves. The end-piece, A, is left loose until the slide is put in, when it is fixed in its place with gum or a couple of small screws.

The different effect slides must now engage our attention.

I will first describe those which are easily arranged and which can be shown with one lantern, and then some of the more elaborate effects for which two or three lanterns and a series of slides will be required; and, lastly, I will explain how certain experiments can be shown in the lantern.

## Silhouette Slides.

*Silhouette Slides* are very amusing, and can easily be made by any one who is clever at cutting out figures in paper. Portraits of friends or public characters are sometimes selected; but grotesque figures are the best. They should be cut out of black paper, and must not be more than about $2\frac{3}{4}$ inches in length. They are gummed on to strips of glass $3\frac{1}{4}$ inches wide, and nine or ten inches long. Another way of preparing them is to cut the figures out of coloured tissue paper, and then to paint in the folds of the drapery, etc., or they can be cut out of white tissue paper, and coloured with transparent colours. The effect is pleasing, but the plain black figures are the most comical, and are, therefore, preferred. They are best shown at the conclusion of an entertainment as a sort of "wind up." All kinds of suitable comic figures stamped out of sheets of paper can be purchased by those who do not care to take the trouble to cut them out for themselves.

Skeleton leaves, sprays of maiden-hair fern, pressed flowers, and similar objects, when mounted between two glasses make interesting slides, and may be shown during an interlude, or if it is desired to lengthen an entertainment.

## The Single Slipping Slide.

A great many pleasing effects may be produced by means of *The Slipping Slide*, shown in Figs. 63 and 64.

As will be seen, there are two glasses mounted in an oblong wooden frame about 7 inches long by $4\frac{1}{4}$ inches wide. One glass is fixed in the frame; the other slides in grooves immediately in front of and as

close as possible to the fixed glass. There is an aperture either square or round in the centre of the frame through which the picture is shown, and which should be about 3 inches across. The figure (in this case a head with a protruding tongue) is painted on the fixed glass, and on the sliding glass a space immediately over the tongue, and sufficiently wide to cover it when the glass is pushed in, is stopped out either with black paint or by gumming a little bit of black paper on to the glass. The slide is shown with the slipping glass (as the latter is called) in, as in Fig. 63. The tongue is not then seen, but will appear to protrude further and further as the glass is drawn out (Fig. 64). The object of cutting the slipping glass off at an angle is to enable you to regulate the sliding movement by fixing a plug in the lower groove to act as a stop when the glass is pulled out far enough. The fixed glass is generally an ordinary square $3\frac{1}{4}$ inch slide glass. The length of the slipping glass must depend upon the distance it is to be drawn out to produce the desired effect. All the plain glass round the figure is generally stopped out on the fixed glass. A great many effects can be shown by means of the slipping glass arrangement; for instance,

Fig. 63.—Slipping Slide (Closed).

Fig. 64.—Slipping Slide (Drawn Out).

the man's nose can be made to elongate, he can be made to grow a beard, etc. A very comical effect could be arranged by painting a long-nosed figure with his thumb to his nose on the fixed glass, and stopping out a space on the other in such a way that when the latter is pulled out the hand is put to the nose, in imitation of the imaginary "coffee mill."

### THE DOUBLE SLIPPING SLIDE.

*The Double Slipping Slide* is arranged in the same way, only there are two slipping glasses instead of one; they should run in grooves on either side of the fixed glass. With this slide we can get a double movement, which, of course, makes the effect more interesting.

Three, and even four, slipping glasses might be used, but they would be rather complicated to arrange as well as awkward to use; and, besides, unless the glasses themselves were very thin, the slide-frame would have to be inconveniently thick; and, further, there would be a difficulty in the focusing. Of course, with the double slipping slide one glass could pull out on one side of the frame and one on the other, or both could be made to pull out on the one side, in which case the end of one glass should be at the top and that of the other at the bottom of the frame.

### THE SINGLE LEVER SLIDE.

*The Lever Slide* consists of two glass discs each about $3\frac{1}{4}$ inches in diameter; one is fixed into a wooden frame with a 3 inch circular opening in the centre, the other is fixed to a flat brass ring of corresponding size, with a lever on one side, by which when put into the frame over the fixed glass it can be partly

turned round. In Fig. 65 a horse is represented standing beside a pond, and in Fig. 66 his head is down, and he appears to be drinking. The body of the horse, the pond, and the various parts of the picture are painted on the fixed glass, and the horse's head and neck on the movable glass; then by merely raising or depressing the lever the horse is made to put his head up or down in a fairly natural way. It should be noticed that the horse's neck is in the exact centre of the two discs, and that the head is on a straight line with the lever. In this class of slide the part where the movement is to begin must always be in the exact centre. The moving glass is kept in its place by means of three little pins driven into the side of the opening or cell. Part of the frame is cut away to give play to the lever as shown. The distance between A and B regulates the movement of the lever. Subjects suitable for this class of slide are children swinging on a log, a man chopping wood, bowing figures, etc., etc.

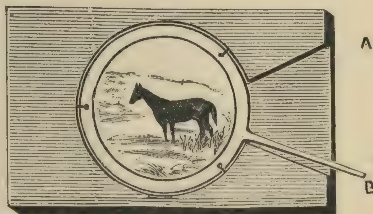

Fig. 65.—Lever Slide (Lever Down).

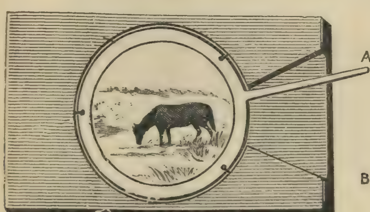

Fig. 66.—Lever Slide (Lever Up).

## The Double Lever Slide.

*Double Lever Slides* have one fixed and two movable discs, the two latter being mounted on separate brass

rings, and let into the frame on each side of the former. Instead of brass rings, tin or stout cardboard rings might be used, a strip being left at one side of the ring to form a lever. The ring should be $3\frac{1}{4}$ inches in external and about 3 inches in internal diameter, and the lever may be 3 or 4 inches long. The glass discs can be gummed on to the ring. A specimen of the double lever slide is shown in Figs. 67 and 68, where we have a ghost waving its arms. An effect of this kind is generally "flashed" on to the screen either by itself or over some suitable picture, such as a churchyard by moonlight: it is then very effective. The arms should be down, as in the first figure, when thrown on to the screen; the arms are then raised and lowered, either together or alternately according to fancy, by working the levers simultaneously or one after the other. When shown with another picture, a second lantern is, of course, required. I should mention that the face of the ghost and the central part of the drapery are painted on the fixed glass, the upper part of which (that surrounding the head) is stopped out

Fig. 67.—Double Lever Slide (Up).

Fig. 68.—Double Lever Slide (Down).

and the left arm and left side of the drapery are painted on one movable disc, the right arm and right side of the drapery on the other; the lower part of the discs and the part surrounding the arms are then stopped out, so that the ghost is shown white on a dark background.

## Conundrum Slides.

*Conundrum Slides* are great favourites with some. They are generally shown by means of the slipping slide arrangement. A piece of blackened cardboard with an aperture 3 inches in diameter in the centre may be substituted for the fixed glass. The conundrum is written within a 3 inch circle near the outer end of the slipping glass, and the answer in a similar circle just beside it. The slide is shown with the sliding glass pushed in, which brings the question opposite to the aperture: then when the glass is pulled out the answer is brought into the aperture.

## Simple Astronomical Slides.

*Simple Astronomical Slides.*—The comparative size of the planets, their orbits, the phases of the moon, eclipses of the sun and moon, the constellations, etc., etc., can easily be shown on the screen by cutting suitable diagrams out of black paper, and gumming them to glasses to form slides. Mr. Woodbury describes a very simple way of preparing a number of diagram slides. He used blackened cardboard and punched holes in it of different sizes to represent the planets, covering the holes thus made with bits of coloured gelatine (the coloured gelatine that is used to decorate crackers will do), selecting the colours assigned to the different planets in the text-books on astronomy. The orbits

can be indicated by making the minutest holes with a very fine needle along the line previously marked out. Jupiter's bands, if the planet is shown on a sufficiently large scale, could be traced in with water colours on white silver paper, or by gumming bands of silver paper of the proper colour over the hole. A diagram to show the phases of the moon would be cut out with a fine sharp penknife. The constellations are marked out with needles of different sizes, using for the first magnitude stars the coarsest needles, and the finest needles for those of the third or fourth magnitude. The colours of the stars can be shown by covering the needle holes with the gelatine films, otherwise they should be left plain, and, in either case, care must be taken not to shut up the holes by rubbing the cards.

## Statuary Slides.

*Statuary Slides.*—Photographic reproductions of statues look very well on the screen; but, unfortunately, are not always shown to the greatest advantage. They are generally stopped out so as to show white on a black background, but unless a slight blue tint is thrown over them from another lantern, or by means of the slide-tinter (Fig. 69), they will have a rather chalky appearance.

## The Slide-Tinter.

*The Slide-Tinter* consists of a metal ring (either brass or tin) to fit on to the nozzle of the objective, with three arms, A, B, C, hinged to it; one, A, forms a shutter, and is made of a piece of japanned tin, 4 inches square; the others, B, C, are metal frames, with grooves to hold sheets of coloured gelatine. The figure shows the arrangement, so that no more detailed description of it

is needed. It is a handy little instrument, but we can produce the effect very well without it by merely holding the gelatine films in front of the objective. The films must always be kept in a book, so as to have them quite flat and uncreased, and the book must be put away in a dry place. Three colours will be quite enough for ordinary purposes—some exhibitors only use two: the most pleasing effect is produced with a violet film; red, if not too deep, is also pretty; blue produces a moonlight effect. It is the best colour to use with statuary slides. A good way of showing these slides, as well as plain photographic transparencies in a single lantern, is to make a frame of either strips of wood or stout cardboard, 10 or 12 inches long and about 4 inches wide; at one end you must put a bit of blackened cardboard, large enough to shut off the light when held in front of the objective. It is cut into teeth so as to form a sort of dissolver. Over the teeth you put two or three sheets of gelatine (blue or violet), then, further on in the frame, one sheet, and then a sheet of paler tint. When this simple contrivance is moved in front of the objective, a pale blue (or violet) tint is seen on the screen: this tint deepens and deepens until the teeth begin to intercept the light, when the picture fades out of sight. The slide must then be quickly changed, and the frame moved back so as to bring on the next picture. A rackwork arrangement for moving the frame could easily be fitted to the

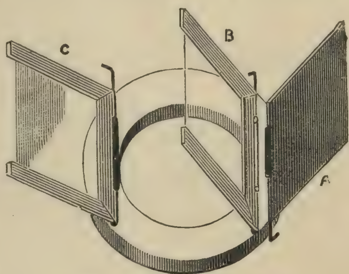

Fig. 69.—Slide-Tinter.

table or lantern stand, but if the tinter is only used now and then, it will scarcely be necessary.

### THE PANORAMIC EFFECT.

Any long view, such as a range of mountains, a wide bay, etc., can be shown as a

*Panoramic Effect.*—The view is painted on a strip of glass, $3\frac{1}{4}$ inches wide and 10 or 12 inches long. The picture is put into one end of the carrier and moved slowly forward. A very much better effect is produced by fixing an ordinary photographic or painted

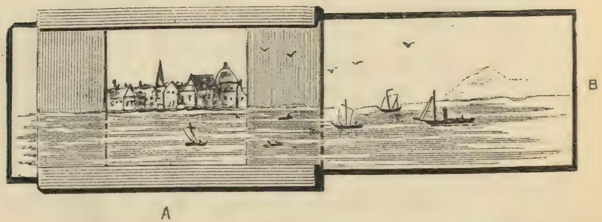


Fig. 70.—Slide Exhibiting Panoramic Effect.

slide into a frame, as in Fig. 70, and on a strip of glass, B, which slides in grooves in the frame immediately in front of the picture, A, painting a number of figures, animals, ships, boats, or other objects suitable to the view. A space on the glass strip, equal to the length of the slide, is left plain at one end, and the picture is first shown without the figures, which can be brought on at any moment by pushing in the glass. If a seascape is to be shown, the effect of rolling waves can be fairly well exhibited by painting a rough sea on two strips of glass, about 3 inches wide; then, by moving the glasses in opposite directions with an undulatory movement, which, as they will move very

freely in the grooves, can easily be managed, the sea will appear to be rolling across the view.

## Rackwork Slides.

*Rackwork Slides* consist of a circular fixed glass with a movable glass in front of it, which latter is made to rotate by means of a rack and pinion arrangement. Fig. 71 shows one of these slides. The mill itself is painted on the fixed glass, and the sails on the movable glass. When the little handle, A, is turned, it works the pinion, B, which rotates the circular glass, and thus makes the sails of the windmill go round. Of course

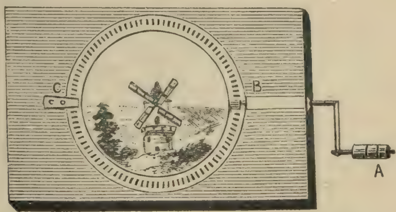


Fig. 71.—Rackwork Slide.

the axle of the sails must be in the exact centre of the glass. The pinion works in a rackwork ring, which is cemented to the upper edge of the movable glass. A little brass peg, C, prevents the glasses from falling out of the frame. A paper or thin cardboard ring should be interposed between the glasses to prevent them from touching. It ought to be gummed on to the fixed glass.

## The Chromatrope.

*The Chromatrope*, sometimes called the Chinese Fireworks Effect, is a never-ending source of delight, particularly to the young folks. It is produced by painting a geometrical pattern on two glass discs, to

which the above-mentioned rackwork rings have been fixed. The discs are mounted in a frame with the rings turned inwards, so that the pinion will work them both at a uniform rate, but in opposite directions. A very brilliant effect, varying according to the rate at which the handle is turned, will then be produced. It is usual to have a number of different designs painted in duplicate on a set of discs (which can be shown in the one frame), so as to produce a series of effects. The designs should be painted in bright colours and

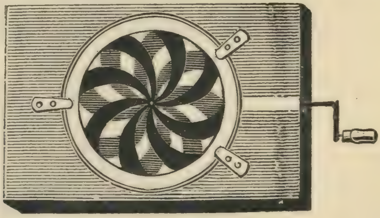

Fig. 72.—Chromatrope Slide.

spiral figures, or those which radiate from the centre are generally the most effective. It is better to paint them in pairs and to show them together, rather than to have a separate design on each disc. Fig. 72 is a representation of one of these chromatrope slides.

I should mention that the frames for all these effects are made of well-seasoned mahogany, and are generally about 7 inches long by $4\frac{1}{4}$ inches wide. The figures show clearly enough how they are made, and a description of them in detail will be unnecessary.

## CHAPTER VIII.

*EFFECTS PRODUCED WITH RACKWORK SLIDES—THE EIDOTROPE—THE KALEIDOTROPE—THE CYCLOIDOTROPE—THE CHOREUTOSCOPE—THE KALEIDOSCOPE—THE SMOKE EFFECT—FOUR SEASONS EFFECT—THE SNOW EFFECT—MOONLIGHT EFFECT—THE STORM EFFECT—THE RAINBOW EFFECT—THE FOUNTAIN EFFECT—THE CASCADE EFFECT—CHEMICAL EXPERIMENTS—GALVANIC EXPERIMENTS—ELECTRO-MAGNETIC EXPERIMENTS—CONCLUSION.*

OTHER EFFECTS PRODUCED BY MEANS OF RACKWORK SLIDES.—A great variety of effects may be produced with the rack and pinion arrangement described in the last chapter. For instance, if we cut out discs of perforated zinc and rotate them in opposite directions, some remarkable designs will be projected on to the screen. If they are covered with coloured gelatine films, the designs will be tinted. Pieces of crape, or muslin dyed black and gummed to the glass discs, produce curious effects, also pieces of black lace, skeleton leaves arranged like the spokes of a wheel, mosquito netting, etc. One of the many chromatic effects can be shown by getting two opaque discs (or stopping out the glass discs with black paper), and making three small round holes in them, so that when put together they will exactly coincide, Fig. 73.

Over each hole you must gum a piece of coloured gelatine, using the three primary colours: the three holes would then show red, blue, and yellow on the screen, but when put into the rackwork frame and made to rotate slowly in opposite directions, where the different films overlap, we shall see on the screen the three secondary colours—green, orange, and purple. This is a pretty experiment, but we sometimes fail to get the green, owing to the blue not being a perfectly pure colour, in which case, of course, we must change it until we get exactly the right shade.

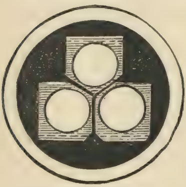

Fig. 73.—Slide Showing Chromatic Effect.

### The Eidotrope.

This is a very surprising effect, also shown by means of the rackwork slide. It consists of two opaque discs of japanned tin or blackened cardboard, in which a series of concentric holes should be punched. When these discs are made to rotate slowly in opposite directions, all sorts of geometrical figures are formed on the screen; when they are turned quickly, scintillations of light, meteor-like flashes, and bright lines of light are obtained.

### The Kaleidotrope.

This is a somewhat similar effect, and serves to illustrate, in a very pleasing manner, what is called the persistence of vision. It consists of an opaque disc, perforated with holes of different sizes and connected to one end of a spiral spring, the other end of which is fixed to a holder or frame; any movement given to the disc will produce circles

and interlacing rings of light on the screen. By varying the movement of the disc you can get some very pretty figures.

### The Cycloidotrope,

also called the Invisible Drawing Master, is a new mechanical slide introduced by Mr. Pumphrey, of Birmingham. With it an infinite variety of most beautiful designs can be produced. It is a rackwork slide, and is worked by a little handle at one side. Fitted to the rackwork ring is a circular smoked glass. This ring in turning works a small cog-wheel, which imparts an eccentric-like motion to a needle bar geared to it. At the end of this bar or lever is a spring carrying a needle, which scratches a line on the smoked surface of the glass, and thus traces a geometrical pattern more or less elaborate, as shown in Figs. 74 and 75. It is evident that the design will depend upon the position of the needle bar, and this is readily altered by simply pushing the bar further in or pulling it out a little. The smoked glass is held in its place by two springs. The smoked glasses can easily be prepared. Mr. Pumphrey recommends rubbing them over first with a very little tallow and then blackening them on one side with the smoke of a common dip candle. They should not be too thickly smoked, or the line will be more or less blurred. The object of greasing them first is to make the needle point work smoothly, and to make the line traced a fine and even one. Before putting a glass on to the ring you must be careful to raise the needle by pushing the spring up the needle bar, and do not let it touch the smoked glass until the latter is fixed in position. You must

also make sure that the needle works within the limits of the glass. A number of glass discs should be prepared at one time, and put away in a tin holder with a cardboard ring or flat india-rubber band of suitable size between them to prevent them from rubbing together.

Very curious effects may be produced by putting

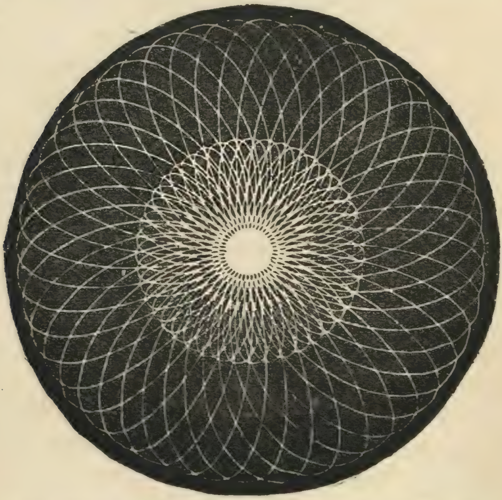

Fig. 74.—Design Drawn by the Cycloidotrope with One Setting of the Needle Bar.

some of these smoked glasses into a chromatrope holder and rotating them in opposite directions. The effects vary according to the rate at which the glasses are rotated.

### The Choreutoscope.

This is a slide for giving life-like motion to figures. The designs are painted upon a strip of glass, which is pushed quickly through the holder. Extra glasses

with painted designs can be purchased for about half-a-guinea each. One of the most amusing is the one called the School Board Director.

## The Kaleidoscope.

This popular instrument has now been adapted to

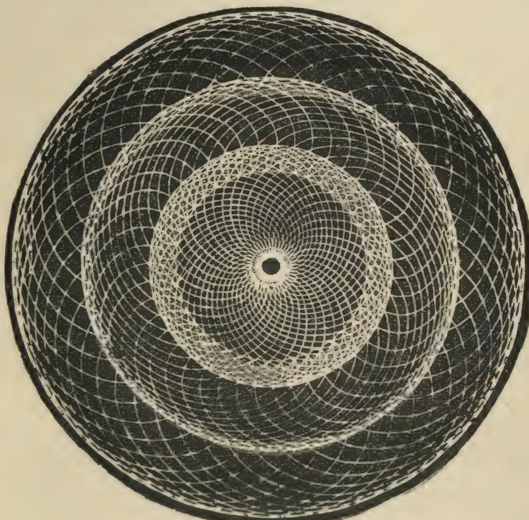

Fig. 75.—Design Drawn by the Cycloidotrope with Three Settings of the Needle Bar.

the magic lantern. Invented many years ago by Sir David Brewster, it is as great a favourite now as it was when first introduced. It was not easy to adapt it to the lantern, but the difficulties to be surmounted have been overcome in a fairly satisfactory manner. It consists of two plain mirrors fitted angle-ways into a brass tube. The mirrors form a V-shaped trough. At each end of the tube there

is a lens, one being a plano-convex and the other a meniscus; the latter is turned towards the lantern.

The objective is removed and the kaleidoscope screwed on in its place. The light must be raised in the lantern so as to bring it above the axis of the condenser. The proper position for the light must be found out by trial. One of the lenses is made to unscrew, so that the mirrors may be dried and cleaned. As the effect is greatly marred when moisture condenses on them, which it is very apt to do, the instrument should be thoroughly dried before it is used. Coloured glass beads, small ears of corn, feathers, a very small pair of scissors, form pretty figures with the kaleidoscope. As a rule the objects to be shown are inserted in a slide-holder and put into the lantern like ordinary slides. When coloured bits of glass or beads or other small objects are shown, they can be put into a chromatrope holder, and made to move so as to alter the form of the figure. The designs shown on the screen are often very striking and effective. As the kaleidoscope requires a very powerful light, it can only be shown with the limelight.

## The Smoke Effect.

For the production of the effects which I am now about to describe, we shall require two (and in some cases three) lanterns.

*The Smoke Effect* is easily shown, and is remarkably effective. It consists of two slides, one an ordinary photographic transparency or painted picture of a volcano (Fig. 76), or steamer, or gipsy encampment, or other subject in which smoke will come in conspicuously. The other slide is a rackwork one, the fixed

glass in which is stopped out except a funnel-shaped space where the smoke is to appear. The smoke is painted in wavy patches along a space, say an inch wide, near the centre of the movable glass, as shown in Fig. 77. The first picture, Fig. 76, is dissolved on; then the smoke slide is put (upside down of course) into the second lantern, and the dissolver pushed back at the same time as the handle, A, is slowly turned. The smoke will then appear to issue in the most natural manner from the crater. The only difficulty in showing this effect, and others of the same class, is in getting the smoke slide in exactly the right position with respect to the other one. It is very evident that if it be pushed in too far or not far enough, the smoke, instead of appearing to come out of the crater, will appear to come out of the sky. It could, of course, be easily altered so as to get it into the right position; but effects lose half their charm if they are not shown right in the first instance. The best way is to try the effects beforehand, and when you get them exactly right to gum a little wedge on to the top of each frame to serve as a stop. If one of the slides should appear too low in the slide-stage, a thin piece of wood gummed on the

Fig. 76.—Smoke Effect (Volcano).


Fig. 77.—Smoke Effect.

to the top of the frame will raise it to the required height. I said "on to the top of the frame," because the picture being always turned upside down, the top, practically speaking, becomes the bottom. It should be observed that the crater is not in the centre of the picture, but a little to the left. The blank space on the fixed glass of the smoke-slide must correspond in size with the mouth of the crater, and in exhibiting the smoke-slide care must be taken to turn the handle the right way, otherwise the smoke will appear to descend. A moment's trial will determine which is the right way. Other subjects can with a little ingenuity be adapted to the smoke-slide, and the effect may thus be exhibited again and again.

### Four Seasons Effect.

This effect is well worth the trouble of arranging. You must have four slides of the same subject, which should be some country scene, a landscape with fields and meadows, an old mill, etc. The first is coloured to represent spring, the second summer, the third autumn, and the fourth winter, with snow and ice. The four slides must be made to register exactly, so that you can dissolve one into another imperceptibly. If the slides are nicely coloured, and figures are introduced engaged in operations appropriate to the different seasons, the effect of the gradual change from spring to summer, from summer to autumn, and from autumn to winter will be very pleasing. When the last picture of the series is shown,

### The Snow Effect

can be introduced. This is probably the most realistic of all the effects, and is at the same time one of

the easiest to produce. Two little rollers are mounted one on either side of a wooden frame or holder of the usual size. Both these rollers can be turned by means of the handles, A and B, Fig. 78; a long strip of black silk, linen, paper, or other opaque material is fastened to them in such a way that it can be wound off one roller and on to the other by turning the handle of the roller on which it is to be wound. A number of pinholes are made in the strip, which holes, when the strip is unwound *upwards*, will look exactly like *falling* snowflakes. A portion of the strip sufficient to cover the opening in the frame should be left at both ends without any pinholes, then a few pinholes should be made, and then more and more as the middle of the strip is approached. The snowstorm will then appear to increase gradually until it attains its full severity, then it will gradually get less and less until it stops. The whole strip should be wound on to the roller, B, before the frame is put into the lantern; then if we turn the handle, A, which is uppermost in the lantern, we shall be certain that the snowflakes will fall. Of course, if we were to unwind the strip downwards, the snow would appear to rise. It is on paying attention to trifles of this sort that much of the success of an entertainment, as a rule, depends. If the snowflakes are not clearly seen, it is owing to the strip being out of focus. The strip should be some 18 inches long.

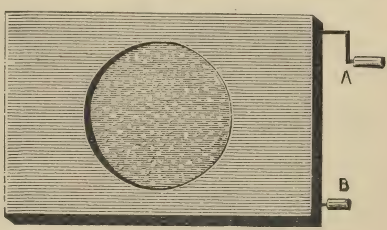


Fig. 78.—Snow Effect.

## Moonlight Effect.

The best way of showing this effect is to have two slides of the same view—one coloured to represent daylight, and the other coloured an intense greenish-blue in imitation of a moonlight view. The two slides being made to register exactly in the lanterns, the daylight scene appears slowly to give place to moonlight by dissolving one into the other. An old ivy-covered castle or abbey is a very favourite subject for this effect, and the ghost previously described can be shown with it. The double lever slide on which the ghost is painted is put into the first lantern in place of the daylight scene, a book is then held in front of the objective, and the dissolver turned aside. The ghost can be flashed on at any moment by quickly moving the book, the levers worked as often as required, and then, at the proper moment, the ghost made to "vanish into thin air" by holding up the book again. If a transparent screen is used, so that the spectators cannot see how the effects are produced, they will appear much more startling. There is another way of showing the ghost, which is sometimes very effective. It is the old-fashioned phantasmagoria arrangement, in which the ghost, when first shown, is quite small, but rapidly increases in size until it becomes colossal in its proportions, filling the whole screen; then it begins to decrease in size until it vanishes. The effect is produced by putting the lantern with the ghost slide close to the screen, and then gradually moving it away from it, altering the focus as you move it until the ghost fills the screen. You then push the lantern back again, reversing the focus until the ghost is flashed off.

If the moonlight scene has an expanse of water, such as a lake or river in the foreground, it might effectively be arranged as a slipping slide. There should be dark clouds in the sky, and a ripple on the water; then by pulling out the slipping glass the moon could be made to appear from behind the clouds, and the beautiful effect of the silvery light dancing on the rippling water could also be shown. In these moonlight views wherever the moon's rays are supposed to fall the glass is left plain, or the lines and patches of light are scratched out on the slide after it is coloured. Another effect that can be produced is that of making a boat or swan glide by on the water. The swan could be mounted as a single lever slide, and then, as it floated across the scene, it could be made to bend its head in a very natural manner. In showing it, you must be very careful not to make it float too far, and also be sure that it floats only on the water, and does not leave its native element and glide over dry land.

All these effects may, with the exercise of a little ingenuity, be varied and extended in dozens of ways. I have not space to do more than explain how the principal effects are produced, and must leave the reader to adapt them to his slides.

## The Storm Effect.

This effect comes in very well after a moonlight scene, or the two effects may be combined. Let us suppose that we wish to exhibit in the most effective way one of our fine old castles—if it is a haunted castle so much the better. We first show it as an ordinary coloured photograph (daylight view); then by moonlight with some of the effects described above; then the

windows can be made to appear as if lighted up and figures shown passing before them; then the sky gets overcast, dark clouds roll up, and lightning flashes in the most natural and vivid manner; then, when the storm is at its height, and the castle itself is nearly obscured, we dissolve it into a room in the castle with one of the inmates starting up at sight of some ghostly figure which passes before the window.

The storm effect is produced by mounting the moonlight view in a frame similar to that used with the panoramic slide described in the last chapter. The clouds are painted on a glass 10 or 12 inches long, which slides in the grooves in front of the view. A space of about 3 inches is left plain at the inner end of this glass, so that the view may first be shown without the clouds. If you wish to light up the windows of the castle, you must have a slipping glass arrangement behind the slide. The windows to be lighted up are coloured a reddish yellow on the slide itself, and a space just sufficient to cover them is stopped out on that part of the slipping glass which would be opposite to them when the glass is pushed in. Close beside these stopped out places, and so arranged as to pass before the windows when the glass is pulled out, you paint the upper half of the figures you intend to show. They must be painted black, and should not be too large or too numerous. When you have made them pass two or three times before the windows, push in the glass which will put out the lights, and proceed with the storm effect. This is shown by pushing the long glass through the frame. The clouds are so arranged as to appear more and more stormy as the outer end of the glass is reached. A greyish tint should be painted over the whole of the latter half of the glass, so as to partly

obscure the view. This tint should at first be faint, and then gradually get deeper; because, of course, as the sky gets dark, the whole scene must get dark too. To heighten the effect the light in the lantern may be slightly turned down. The lightning slide, Fig. 79, is put into the other lantern, and flashed on and off as quickly as possible and as often as required.

This slide is very easily made. It is merely a stopped-out glass, on which a zigzag line has been scratched out and coloured a brilliant yellow. This line, when flashed on to the dark clouds, has exactly the appearance of lightning, and can be shown on different parts of the sky by moving the slide in the lantern or the lantern itself. If you move the lantern you must remember that a very slight movement will produce a considerable alteration in the position of an object on the screen.

Fig. 79.—Lightning Effect.

The effect of the apparition at the window is produced by means of two slides: one is an ordinary coloured slide representing one of the rooms in the castle, with a large window near the middle. This is shown first, and the second one is put into the other lantern and brought on when required. It is a slipping slide, the fixed glass of which, with the exception of a space exactly equal to the size of the window, is stopped out. The window frame is marked out in black lines, also the curtains and hangings, if there are any. The apparition is painted on the slipping glass, and the glass all round it is stopped out. When the slipping

glass is pushed in, the apparition will, of course, be hidden behind the opaque part of the fixed glass, but on drawing it out the form will appear to pass before the window outside the building. The effect may be shown in another way. The apparition is painted in the space left for the window (the framework being clearly marked out over it), the light in the lantern is then turned down, the slide put in, and the light gradually turned up; the ghostly form will then appear to grow out of the darkness. Then the light is gradually turned down, and the apparition fades away again into the darkness. The slipping slide is not in this case required.

### The Rainbow Effect.

This pleasing effect can be produced in two ways, either by painting a rainbow as an ordinary slide and projecting it on to the sky of a suitable view, or by means of a prism. The former is the simpler method, but the latter is the more natural and surprising. In either case, two lanterns are required. When the rainbow-slide is used all the glass round the coloured band must of course be stopped out, and the light in the lantern should be lowered so that only a faint image of the rainbow may be seen. When the effect is produced by means of a prism, a black card with a bow-shaped slit is put into the carrier of the second lantern; this, of course, would show as a white band on the screen; but on holding an ordinary prism in front of the objective, the white band vanishes, and in quite a different part of the screen, or it may be on the floor or on the ceiling, a rainbow-tinted band will be seen. By tilting the lantern this coloured band, which is really a very good imitation of a rainbow, can be brought into

the proper position on the screen, and shown in connection with a waterfall or some other appropriate subject.

## Fountain Effect.

Two slides and the slide tinter (or a set of gelatine films) are required for this very pretty effect. One slide represents a fountain, with the usual mermaids, dolphins, and other figures, from which jets of water are thrown up, and the basins, etc., into which the water falls. The other slide is a rackwork arrange-

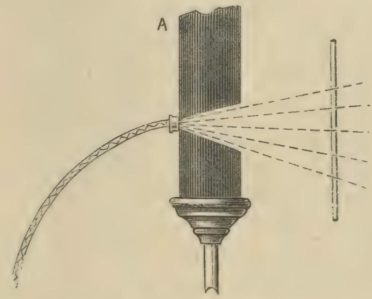


Fig. 80.—Cascade Effect.

ment of three glasses, on two of which wavy lines are painted of a very delicate grey or blue grey tint in resemblance of water. These glasses being rotated in opposite directions, a very good representation of falling water will be the result. The third glass, which is placed before the others, is stopped out, clear spaces, however, being left in it wherever the jets of water are to appear. The slide-tinter greatly enhances the effect by colouring the water. Three lanterns should be used when this effect is shown, so that you can bring on the

next picture without having to stop the fountain, which should be kept working all the time it is being exhibited.

## THE CASCADE EFFECT.

This is a beautiful experiment with real water. Only one lantern is required, and the objective is removed. In its place is stood the upright glass vessel, A, Fig. 80. The vessel has a small hole bored at one side, from which, when filled with water, a fine unbroken stream will flow, as shown in the figure. The whole surface of the vessel is stopped out, with the exception of a circular space opposite the hole, just large enough to allow the rays of light proceeding from the condenser to pass through the vessel, which is so placed that the point of the focus may be exactly at the orifice.

If the light is now turned on in the lantern, the stream of water will be most brilliantly illuminated. Gelatine films, placed between the condenser and the vessel, will tinge the water. If the light is momentarily interrupted by waving a stick in front of the condenser, the water will resemble golden balls. Three things must be noted to insure success: first, that the vessel is the right distance from the condenser; second, that the hole is smooth and perfectly round, so that the water issues from it in a regular flow (a glass tube is sometimes fitted into the hole, as shown in the figure, to form a spout); and, thirdly, that there is no draught to disturb the stream.

## CHEMICAL EXPERIMENTS.

These are so numerous that even to name them would require pages. I will, therefore, confine myself

to describing two or three as examples of the many uses to which the lantern can be put.

For chemical experiments, a glass cell, Fig. 81, is indispensable; two or three glass rods and pipettes, which are glass tubes with an india-rubber ball at one end, and drawn to a point at the other end, will also be required. The cell can easily be made out of two pieces of plate-glass fitted with marine glue into a varnished wood-frame, or clamped together with a piece of india-rubber about half an inch thick between them. This cell is inserted in the slide-stage in place

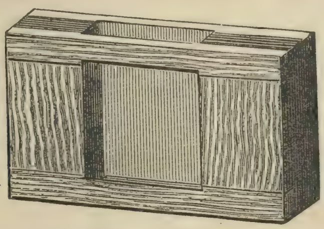

Fig. 81.—Glass Cell for Chemical Experiments.

of the carrier. If you intend to show a number of experiments, you ought to have at least half a dozen of these cells, to save time in washing them out.

Put a weak solution of nitrate of silver into the cell, and suspend a copper wire in the solution. The wire will very soon become encrusted with silver, the actual deposition being clearly shown on the screen.

Put some alcohol into the cell, and carefully let a single drop of one of Judson's dyes fall into it. A very pretty tree-like figure will be formed. A drop of another colour may be put into a different part of the cell, so as to produce a second tree, the branches

of which will interlace beautifully with those of the first one.

The well-known experiments of changing the colour of certain fluids, by dropping acids or alkalies into them, are very easily shown.

The development of a photograph can be shown on the screen—in act, the whole process of photography, from the coating of the glass, in the first instance, to the final production of a finished positive, can be demonstrated to a numerous assembly in the most striking manner by means of the lantern; of course, the room must be dark while the plate is being coated, and the development must be carried on in a cell having, on the side nearest the condenser, a ruby coloured glass. The light from the lantern will be sufficient to print the picture or to take a negative, if one of the rapid emulsions is used, the exposure being determined by previous trial. These photographic experiments are amongst the most effective that can be shown on the screen. There is, for most persons, a fascination in watching the lines of the image gradually appearing on the screen, as if they were being traced by an invisible hand.

## Galvanic Experiments.

Probably the most interesting of this class of experiments is that for showing the action of the electric current, in depositing one metal upon another. You will require a small battery (one or two cells, pint size, of a bichromate battery will do), a piece—say half an inch square—of thin sheet gold, a piece of copper gauze of the same size, a couple of pieces of copper wire, two binding screws, and a short stick of cyanide of potassium (this being a deadly poison, must

be carefully handled). You begin by fastening the binding screws, one to each end of your cell; then fix the wires to them, and connect the gold sheet to one wire and the copper to the other, and let them hang opposite to each other in the cell, close together but not touching. Put the cyanide into the bottom of the cell and fill it up with water, then connect the two poles of the battery with the binding screws by means of two insulated wires, and immediately bubbles will be seen passing off from the gold plate, and very soon the plate itself will show signs of wearing away, while particles of metal will be carried across to the copper gauze, the meshes of which will presently be filled up. The bubbles are, of course, globules of hydrogen, obtained by the decomposition of the water. In connecting up the battery the negative pole (zinc end) must always be connected with the copper gauze (called the cathode), and the positive pole with the gold or anode.

The decomposition of water, the deflection of the magnetic needle, under the influence of the galvanic current, and many other similar experiments can be performed. The amateur electrician will easily be able to arrange the requisite apparatus for exhibiting them in the lantern.

## Electro-Magnetic Experiments.

A small electro-magnet, the poles of which are bent towards each other, should be fitted into an ordinary slide-frame. Its outline can then be projected on to the screen. What are called the magnetic lines can be shown by letting some fine iron filings fall between the poles. The first filings will cluster round the poles, and if more are sprinkled

over them, they will bridge over the space in the form of a series of semicircles or arches. The single cell bichromatic battery may be used with this electro-magnet, or any other battery that the amateur may have by him.

THE END

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